Actes de la
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SUR LA LUTTE CONTRE MICONIA

Proceedings of the
FIRST REGIONAL CONFERENCE ON MICONIA CONTROL

26-29 AOUT 1997 / AUGUST 26-29, 1997
PAPEETE, TAHITI
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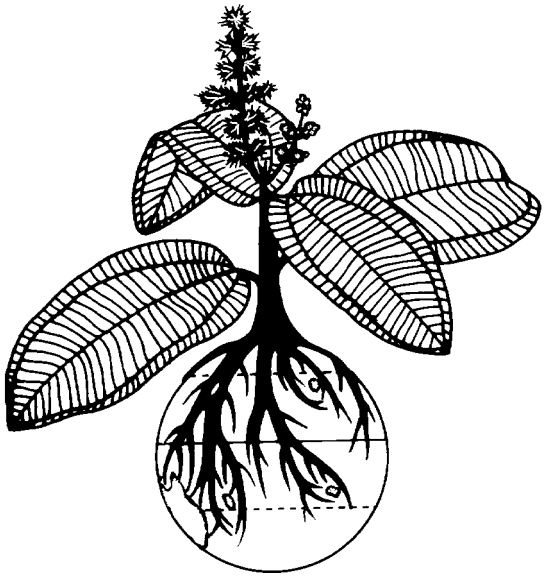

édités par / edited by

J.-Y. MEYER & C. W. SMITH

Gouvernement de Polynésie française/University of Hawaii at Manoa
Centre ORSTOM de Tahiti

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Photo (Eloise M. KILLGORE©) :

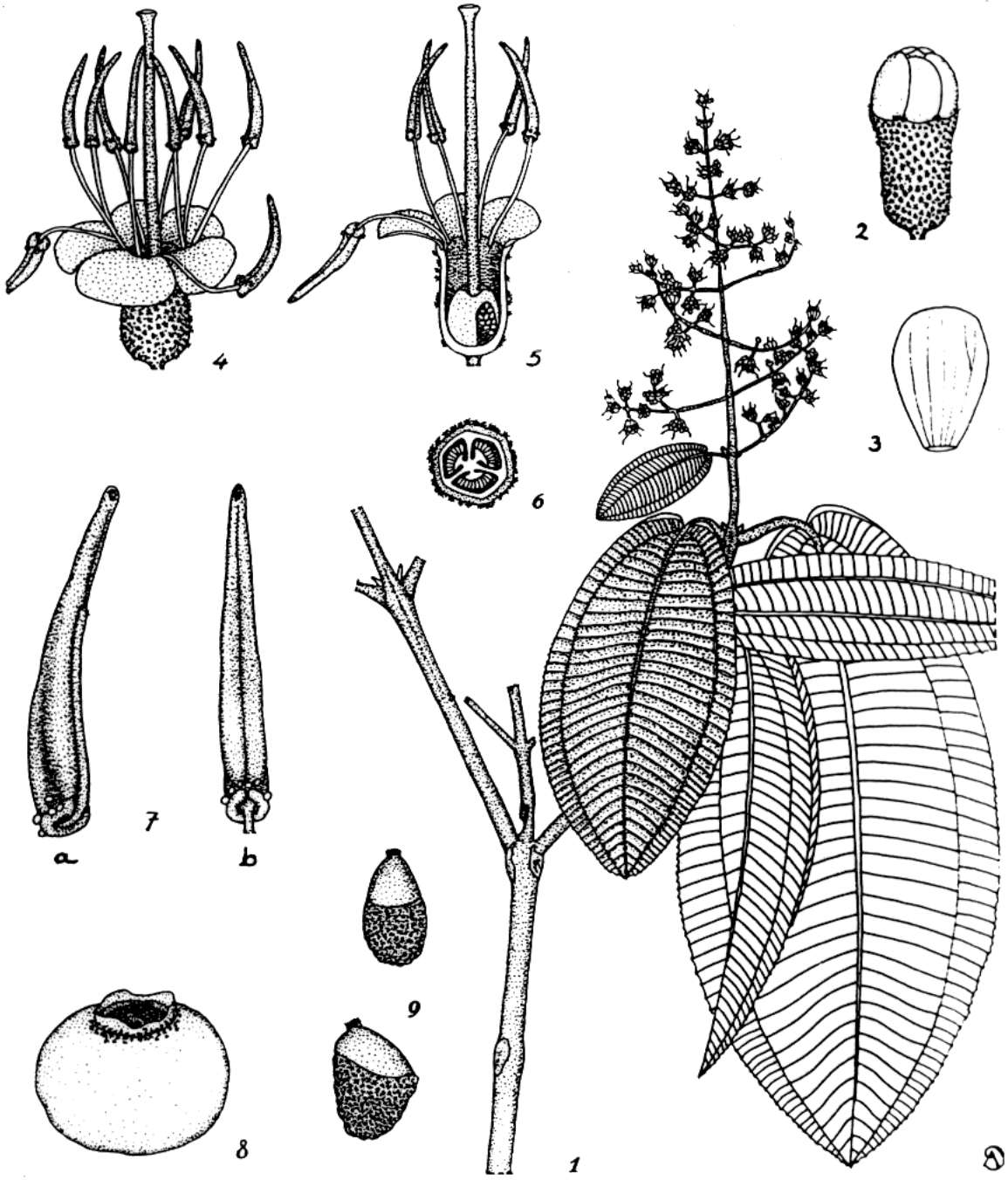
Forêt monospécifique de *Miconia calvescens* sur le plateau de Taravao (Tahiti, Polynésie française) avec un couvert dense de plantules dans une petite trouée de lumière (29 août 1997).

Monospecific forest of Miconia calvescens *on the Taravao plateau (Tahiti, French Polynesia) with a dense cover of seedlings in a small light gap (August 29, 1997).*

PLANCHE BOTANIQUE

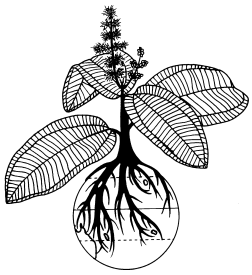
Miconia calvescens DC (syn. *Miconia magnifica* Triana)

(MYRTALES, Melastomataceae : Melastomatoideae, Miconieae)



1. tiges legèrement pubescentes, feuilles opposées 5-nervées avec trois nervures proéminentes, et inflorescence terminale (x 1/3) ; **2.** bouton floral au calice recouvert d'une pubescence étoilée (x 13) ; **3.** pétale oboval blanc à nervation palmée (x 13) ; **4.** fleur épanouie 5-mère au style proéminent et avec 10 étamines (x 13) ; **5.** coupe longitudinale d'une fleur épanouie (x 13) ; **6.** coupe transversale de l'ovaire (x 13) ; **7.** anthère au pore apical et avec de petites glandes basales, au stade bouton floral a) et au stade de fleur épanouie b) ; **8.** baie charnue noire à maturité (x 10) ; **9.** graines pourvues d'un tégument coriace (x 65) (Dessin : A. DETTLOFF)

1. *thinly puberulous stems, opposite 5-nerved leaves with three prominent nerves, and terminal inflorescence (x 1/3);* ***2.*** *floral bud with hypanthium covered with small stellate hairs (x 13);* ***3.*** *white obovate petal with a palmate nervation (x 13);* ***4.*** *opened 5-merous flower with a prominent style and 10 stamens (x 13);* ***5.*** *longitudinal cut of an opened flower (x 13);* ***6.*** *transversal cut of the ovary (x 13);* ***7.*** *anther with a terminal pore and basal small glands ;* ***8.*** *fleshy berry black when ripe (x 10);* ***9.*** *seeds with a a hard seed coat (x 65). (drawn by A. DETTLOFF)*



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PRÉFACE

1997. Le choix de l'année 1997 pour organiser **la Première Conférence Régionale sur la Lutte contre *Miconia calvescens*** (*M.c.*) était, en partie, de célébrer le 60ème anniversaire de l'introduction (malheureuse) de cette espèce végétale comme plante ornementale au Jardin botanique Harrison Smith de Tahiti en 1937. Cette plante introduite est rapidement devenue une "peste végétale", que ce soit en Polynésie française ou aux îles Hawai'i, et l'un des exemples les plus connus d'une invasion biologique dans un écosystème insulaire. Il était devenu nécessaire de faire une synthèse sur la biologie de *M.c.* et sur les différents moyens de lutte. Ainsi, le principal objectif de la conférence a été de faire le bilan de plusieurs années d'étude et de gestion de *M.c.* dans la région du Pacifique, plus particulièrement en Polynésie française et aux îles Hawai'i, afin de pouvoir réévaluer ce qui doit être entrepris. Cette conférence a été également l'occasion pour les agents des services gouvernementaux, les gestionnaires des milieux naturels et les chercheurs de se réunir et d'échanger leurs idées et points de vue de façon informelle.

Les opérations de lutte initiées dès 1990 sur l'île de Raiatea (Archipel de la Société) et dès 1991 sur l'île de Maui (Hawai'i) se sont fortement intensifiées d'année en année. Par exemple, les Forces armées françaises sont intervenues durant les campagnes d'arrachage de 1993 et 1997 en Polynésie française. Des comités d'action ont été créés contre *M.c.* et d'autres espèces de la famille des Mélastomatacées à Maui en 1991 et à Hawai'i en 1995. Aux îles Hawai'i, chaque niveau du gouvernement, du bureau du Gouverneur jusqu'aux Comtés, soutient les efforts pour contenir *M.c.* dans les îles et d'importants financements sont directement débloqués pour lutter contre cette seule espèce. Des actions juridiques ont également accompagné les activités de lutte. Déclarée "espèce nuisible" en Polynésie française depuis 1990 (Arrêté N°290 CM) et reclassée "espèce menaçant la biodiversité" en février 1998 (Arrêté N°244 CM), *M.c.* fait partie de la "Noxious Weed List" des îles Hawai'i depuis 1992 (Hawaii Administrative Rules, Title 4, Subtitle 6, Chapter 68, Noxious Weed Rules) et a été interdite de culture et de vente dans toute la région du Queensland en Australie en mai 1997.

L'année 1997 est également marquée par la signature d'une convention de collaboration entre le Gouvernement de Polynésie française et le State of Hawaii Department of Agriculture pour développer un programme de lutte biologique classique contre *M.c.* Une expédition scientifique est prévue en juin-juillet 1998 au Guatemala, dans la région d'origine de *M.c.*, pour y rechercher des ennemis naturels de cette plante. Cet événement renforce la collaboration engagée depuis septembre 1996 avec les chercheurs et gestionnaires de l'Université de Hawai'i et des Parcs nationaux de Hawai'i. Il illustre aussi le fait que la coopération internationale entre gouvernements peut être rapidement réalisée pour s'attaquer aux problèmes causés par les espèces envahissantes.

1998. La publication des Actes de cette Conférence marque les 10 années du lancement du **Programme de Recherche sur Miconia**, initié en 1988 conjointement par le Gouvernement de Polynésie française et l'ORSTOM. Malgré les nombreuses difficultés rencontrées tout au long de ce programme (absence d'équipe de recherche, financements et moyens logistiques insuffisants), les résultats scientifiques obtenus, tant au niveau de la recherche fondamentale que de la recherche appliquée sur le terrain, sont considérables. Les présentations orales exposées lors de la Conférence et retranscrites dans cet ouvrage montrent que l'origine, la bio-écologie et la répartition de *M.c.* sont maintenant bien connues ; elles démontrent que les stratégies et les méthodes de lutte actuellement utilisées

sur le terrain ont montré leur efficacité ; enfin, elles illustrent que les campagnes d'information et d'éducation du public et des autorités sont bien perçues, comme le souligne la réaction favorable des autorités gouvernementales et le vaste soutien du public.

Le Programme de Recherche sur Miconia en Polynésie française, tel qu'il avait été conçu à l'origine en 1988, a fait place en 1998 à un Programme de Gestion de l'invasion par Miconia plus général. Cette transformation reconnaît l'importance que toute action doit être précédée avant tout par des travaux de recherche permettant de mieux connaître l'espèce-cible. Ce programme de gestion, financé par le Contrat de Développement État-Territoire, et intégre plusieurs volets indispensables et indissociables : recherche, action, législation, information et éducation.

Cependant, et malgré plusieurs années d'efforts de lutte sur le terrain et de campagnes de prévention et d'information contre l'extension de *M.c.*, le combat n'est pas encore gagné : au moment où ces Actes sont rédigés, nous venons d'apprendre que *M.c.* a été trouvé sur l'île de Rurutu (Australes), et que sa présence sur l'île très isolée de Rapa est possible. Rapa, étant l'un des 3 principaux centres de la biodiversité en Polynésie française (avec Tahiti et Nuku Hiva) et offrant un milieu naturel favorable au développement de *M.c.*, l'introduction de cette plante envahissante dans cette île serait une nouvelle catastrophe écologique pour la Polynésie française, et une action vigoureuse et immédiate doit être engagée. Nous avons été également récemment informé de la découverte de plusieurs populations de *M.c.* dans le petit village touristique de Kuranda, situé à 40 km à l'Ouest de Cairns dans la région du Queensland en Australie. Plus de 500 plants, dont les plus grands atteignaient 8 m de hauteur, ont été rapidement détruits, et des campagnes d'information du public ont été lancées (communication personnelle de P. Davis, Land Protection Officer, Atherton, North Queensland).

Il n'est pas surprenant de constater que de nombreux ouvrages et articles scientifiques d'importance internationale parus ces dernières années font maintenant référence au cas particulièrement spectaculaire et catastrophique de *M.c.* à Tahiti . Cette espèce est maintenant citée comme l'exemple typique d'une plante introduite devenue envahissante dans les îles du Pacifique par le Programme Régional Océanien sur l'Environnement (Given, D. 1992. The South Pacific Biodiversity Programme, SPREP, Apia : 7) et par l'Union Mondiale pour la Nature (McNeely J. A., Harrison J., and P. Dingwall (eds.). 1994. Protecting Nature : Regional Reviews of Protected Areas, IUCN: 274). Il est enfin remarquable et significatif de noter que la dernière édition du dictionnaire des plantes vasculaires (Mabberley, D. J. 1997. The Plant Book, A Portable Dictionary of the Vascular Plants, Cambridge University Press : 454), ouvrage de référence pour les botanistes, a rajouté dans son paragraphe consacrée au genre *Miconia* une citation sur l'extension de *M.c.* dans les forêts naturelles de Tahiti qui n'y était pas dans la première édition datant de 1987.

Ces années d'expérience collective acquises dans la gestion de l'invasion biologique par cette plante introduite extrêmement agressive ont souligné la nécessité :

1) d'une collaboration étroite et coordonnée entre les organismes de recherche, les services gouvernementaux, les associations ou ONG et les autres volontaires, pour intégrer plus efficacement les efforts entrepris pour prévenir l'introduction et l'établissement des plantes envahissantes aussi bien que pour contrôler celles qui sont déjà présentes ("les espèces envahissantes ne respectent pas les structures gouvernementales" soulignait J. Waage de l'Institut International de Lutte Biologique lors du congrès mondial sur les espèces introduites envahissantes, organisée au Canada par l'UICN en 1996) ;

2) d'une collaboration accrue entre les pays insulaires de la région du Pacifique afin d'éviter le phénomène redouté de l'homogénéisation progressive et insidieuse de leurs flores, souvent riches et originales, par des invasions biologiques. L'érosion de la

biodiversité signifie en effet, dans les îles du Pacifique, non seulement la perte d'un patrimoine naturel mais également la disparition d'un héritage culturel.

3) d'une meilleure participation de tous ceux qui participent à l'échange d'informations et d'idées à travers des réseaux, tels que Internet.

Papeete & Honolulu, avril 1998.

J.-Y. MEYER & C. W. SMITH

FOREWORD

1997. The choice of 1997 for the **First Regional Conference on *Miconia calvescens* Control** was, in part, to recognize the 60th anniversary of the (unfortunate) introduction of this alien species as an ornamental plant to the Harrison Smith Botanical Garden, Tahiti, in 1937. It rapidly became a “plant pest” both in French Polynesia and Hawai’i, and is becoming one of the most widely known example of the destructive impact of a biological invasion into an insular ecosystem. There was an impending need to synthesize what we knew about its biology and control. The main focus of the conference, therefore, was to assess several years of study and management of *M.c.* in the Pacific region, particularly French Polynesia and Hawai'i, and reevaluate what needs to be done. It also provided an opportunity for government administrators, managers and researchers to get together and exchange ideas and concerns informally.

Control operations, initiated in 1990 on the island of Raiatea (Society Islands) and 1991 on the island of Maui (Hawai'i), have increased dramatically each succeeding year. For example, the French Army took part in the removal campaigns in 1993 and 1997 in French Polynesia. Action committees were set up against *M.c.* and other plant species of the Melastome family on Maui in 1991 and on Hawai'i in 1995. In Hawai`i, every level of government, from the Governor's office down to the County government, are supporting the efforts to contain *M.c.* in the Islands and large sums of money are being directed against this one species. Legislative action has kept pace with control activities. Classified as a harmful species in French Polynesia since 1990, (Decree N°290 CM) and re-classified as a "species threatening biodiversity" in February 1998 (Decree N°244 CM), *M.c.* was also included on the "Noxious Weed List" of Hawai'i in 1992 (Hawai'i Administrative Rules, Title 4, Subtitle 6, Chapter 68, Noxious Weed Rules). Furthermore, cultivation and sale of *M.c.* was prohibited in Queensland, Australia, in 1997.

1997 was also the year when a cooperative agreement was signed between the Government of French Polynesia and the State of Hawai'i Department of Agriculture to develop a classical biological control program against *M.c.* An exploratory expedition is already planned in June-July 1998 in Guatemala, in search of natural enemies of *M.c.* in its native range. This document strengthens the cooperation initiated in September 1996 with the researchers and managers of the University of Hawai'i and the National Parks of Hawai`i. It also illustrates that international cooperation between governments can be achieved rapidly to address invasive species problems.

1998. The publication of these Conference Proceedings marks the 10th anniversary of the start of the **Miconia Research Program** in French Polynesia, jointly initiated in 1988 by the Government of French Polynesia and ORSTOM. In spite of numerous difficulties, the scientific results achieved, both basic and field-oriented applied research, are considerable. The presentations made during the Conference document the origin, bio-ecology and the distribution of *M.c.* in detail; demonstrate that the control strategies and methods that are currently used in the field are effective; and, illustrate that the public awareness and educational campaigns have worked as shown by the response of government authorities to this scourge and the widespread public support.

The Miconia Research Program in French Polynesia, as devised at the beginning in 1988, by 1998 evolved into a more general Miconia Management Program. This transformation is an important recognition by all concerned that action against this species had to proceed before all of the research was completed. This program, funded by the (French) State - (Polynesian) Territory Development Contract, includes several essential and inseparable elements: research, action, legislation, information and education.

In spite of several years of control efforts in the field, however, as well as prevention and information campaigns against *M.c.* propagation, the struggle has not been won yet. Even now, as these proceedings were being drawn up, we were informed that *M.c.* has been found on the island of Rurutu (Austral Islands) and that it might be present on the remote island of Rapa as well. Rapa is one of the three major biodiversity hot spots in French Polynesia (with Tahiti and Nuku Hiva). Since the island provides favorable habitat for *M.c.*, the introduction of this invasive plant to that island is another potential ecological disaster for French Polynesia that must be met with immediate and vigorous action. We have also been informed that several populations of *M.c.* have been discovered recently in Kuranda, a small tourist village located 25 miles to the west of Cairns, Queensland, Australia. More than 500 plants, some 8 m tall, were immediately destroyed and public awareness campaigns initiated (P. Davis, Land Protection Officer, Atherton, North Queensland, pers. comm., 1998).

It is not surprising to see that recently-published scientific books and papers of international importance now refer to the particularly dramatic and spectacular case of the invasion of *M.c.* in Tahiti. This species is now quoted as the worst-case example of an introduced plant that became invasive in the Pacific Islands by the South Pacific Regional Environment Program (Given, D. 1992. The South Pacific Biodiversity Programme, SPREP, Apia: 7) and by the International Union for the Conservation of Nature (McNeely J.A., Harrison J., and P. Dingwall (eds.), 1994. Protecting Nature: Regional Reviews of Protected Areas, IUCN: 274). It should be noted also that the latest edition of the dictionary of vascular plants (Mabberley, D.J. 1997. *The Plant Book. A Portable Dictionary of the Vascular Plants*, Cambridge University Press: 454) has now added in its paragraph concerning the genus *Miconia* a quote on the invasion of *M.c.* in the native forests of Tahiti, a fact not presented in the first edition of 1987.

Our collective experience in the management of the invasion by this extremely aggressive, alien plant stresses the need for:

1) closer coordination and cooperation between land managers, government administrators, conservationists, scientists, NGOs and volunteers to more effectively integrate efforts to prevent the introduction and establishment of invasive plants as well as control and eradicate those already present. "Invasive plants do not respect government structures" (J. Waage of the International Institute of Biological Control stressed during the international conference on invasive introduced plant species organized in Canada by IUCN in 1996);

2) increased cooperation between the countries of the Pacific region in order to avoid the progressive and insidious homogenization of their floras, which are often rich and unique, by biological invasions. Indeed, in the Pacific Islands, the erosion of biodiversity does not only mean the loss of natural resources but also the disappearance of a cultural heritage.

3) better participation by all concerned in efforts to exchange information and ideas via networks, and services provided on the internet.

Papeete & Honolulu, April 1998.

J.-Y. MEYER & C.W. SMITH

DISCOURS D'OUVERTURE DU PRÉSIDENT DU GOUVERNEMENT DE LA POLYNÉSIE FRANÇAISE

lu par **M. Édouard FRITCH**, Vice-Président,
Ministre de la Mer, du Développement des Archipels et des Postes et Télécommunications

Mesdames et Messieurs,

Le Président du Gouvernement de la Polynésie française qui ne peut être parmi nous aujourd'hui m'a demandé de me faire l'écho de l'attention que porte le Gouvernement au problème du Miconia.

En juin 1992, le premier sommet mondial sur la planète Terre, communément appelé conférence de Rio, a porté sur la scène publique, la notion de "biodiversité" jusqu'alors connue des seuls scientifiques.

Si les résolutions prises alors, ont malheureusement peu été suivies d'effets, elles ont eu le mérite de souligner l'enjeu que représente la conservation de la diversité biologique et les dangers auxquelles elle est soumise.

Le message délivré, ne préconise pas de figer l'état d'une nature idéale, mais propose d'accompagner son évolution dans un souci de développement maîtrisé et durable.

L'histoire du progrès humain est en premier lieu l'histoire de la domestication de la nature, de son adaptation contrainte au développement de la vie humaine.

Nos ancêtres n'ont-ils pas apporté lors des premiers peuplements de la Polynésie des espèces animales et végétales qui n'existaient pas, modifiant ainsi fondamentalement l'ordre naturel préexistant ?

Ce qui est nouveau, c'est le pouvoir exorbitant d'hypothéquer l'avenir par nos actes présents, que nous donne depuis peu notre degré de développement.

En un siècle, l'humanité a libéré des forces capables d'influer sur les grands phénomènes de la Nature.

Ainsi le climat de la planète, en raison d'une production artificielle de gaz carbonique, connaît un réchauffement significatif qui renverse la tendance naturelle à la glaciation.

Ainsi 50 000 espèces animales et végétales disparaissent chaque année en raison d'une activité humaine incontrôlée qui dilapide le capital accumulé par des centaines de millions d'années d'évolution.

Malgré une prise de conscience naissante, ces phénomènes sont encore insuffisamment connus du grand public et mal appréciés des autorités qui ne mesurent pas pleinement les effets qu'ils portent en germe.

La submersion des basses terres, la fragilisation de l'agriculture, les changements climatiques, la rupture des équilibres écologiques et leur cortège de désordres économiques et sociaux, sont autant de bouleversements à venir dont la gestion devrait commencer dès aujourd'hui.

Les invasions biologiques sont moins spectaculaires. Elles n'en représentent pas moins un risque écologique majeur, de nature à mettre en cause les écosystèmes les plus fragiles.

Lors de la conférence internationale sur les espèces végétales introduites qui s'est tenue en juillet 1996 en Norvège, les experts ont estimé que les invasions d'"aliens" constitueront au prochain siècle, la première menace pour la biodiversité, avant même la perte d'habitat.

Leur coût économique pour les seuls États-Unis a été évalué à plus de 100 Milliards de dollars.

De nombreux exemples dans l'histoire ont démontré que la nature est parfois capable de rétablir d'elle-même les équilibres menacés. Des expériences d'éradication de plantes indésirables ont réussi en Afrique du Sud, en Nouvelle-Zélande ou en Australie. Mais je sais que le pessimisme l'emporte chez les scientifiques, compte tenu de l'ampleur des phénomènes réçents, et du peu d'écho qu'ils suscitent auprès des autorités. Leur contrôle nécessite pourtant des moyens multidisciplinaires importants, coordonnés et pérennes.

L'envahissement sans partage de la Méditerranée par l'algue *Caulerpa taxifolia* depuis 1984, peut hélas valoir de modèle, tant par son intérêt scientifique, que par l'insuffisance de sa prise en compte par les autorités.

En Polynésie française, la gestion maîtrisée du patrimoine naturel est sans doute une matière encore plus sensible qu'ailleurs.

La superficie du Territoire est réduite, son écosystème insulaire fragile, enfin, sa population connaît une très forte croissance, ses plus grandes richesses sont issues d'une nature encore généreuse.

Vous le savez, la Polynésie française tire l'essentiel de ses ressources propres du tourisme, de la perle noire et de la pêche, qui sont des secteurs d'avenir, porteurs de croissance et d'une plus grande indépendance économique.

L'engouement pour les substances naturelles exotiques ou dotées de vertus remarquables, ouvre également des opportunités non négligeables à l'économie polynésienne. Le jus de Nono (*Morinda citrifolia*), le Kava (*Piper methysticum*), l'huile de Tamanu (*Calophyllum inophyllum*) et bien d'autres huiles essentielles, peuvent trouver auprès de la vanille, une place privilégiée dans l'activité exportatrice de la Polynésie française, si tant est que l'exigence de qualité imposée par les marchés internationaux est respectée.

Mais toutes ces perspectives de développement ne deviendront concrètes que dans le cadre d'une gestion maîtrisée des ressources naturelles qui en sont à l'origine.

L'organisme de protection de l'environnement "Conservation Internationale" classe hélas la Polynésie parmi les 17 points chauds du globe qui connaissent les atteintes les plus graves à la biodiversité.

L'histoire des invasions biologiques en Polynésie française est riche et ancienne. Loin d'être exhaustif, je citerai parmi les introductions récentes particulièrement nuisibles, le Nono des plages (*Culicoïdes belkini*) importé en 1959 des îles Fidji, qui hante les plages des Iles-Sous-le-Vent et des Tuamotu, et portant préjudice aux activités touristiques. Je citerai le Merle des Moluques (*Acridotheres tristis*), qui pullule dans les îles de la Société. Je citerai l'escargot carnivore *Euglandina rosea* introduit en 1974 en provenance de Guam, qui a

dores et déjà entraîné la disparition de 9 espèces de *Partula* à Moorea et de nombreuses autres espèces dans les îles de la Société.

Le Miconia (*Miconia calvescens*) qui nous réunit aujourd'hui, a été introduit en 1937 comme plante ornementale. En s'échappant du jardin botanique de Papeari auquel il était destiné, il a entamé une lente mais régulière invasion des régions humides de montagne.

Je laisserai aux intervenants scientifiques le soin de nous décrire son degré de prolifération, particulièrement alarmant sur l'île de Tahiti, et ses conséquences catastrophiques sur la flore locale.

Je veux pour ma part, illustrer mes précédents propos, en soulignant les risques graves qu'entraîne l'expansion hégémonique du Miconia sur l'activité touristique dépendante de la beauté du paysage, sur l'agriculture et sur la qualité de notre cadre de vie qui fait l'attrait de la Polynésie.

Dès 1988 le gouvernement du Territoire a mis en place avec la collaboration précieuse de l'ORSTOM les premiers programmes de recherche destinés à mieux identifier le phénomène.

Des campagnes d'arrachage sont régulièrement entreprises depuis 1992 aux Iles-Sous-le-Vent, par les agents du Service du Développement Rural, avec le concours essentiel et jamais démenti des Forces Armées.

Amiral, soyez en remercié très chaleureusement et vos hommes avec vous.

Plus récemment enfin, dans le cadre du contrat de développement, le Gouvernement de la Polynésie française a conclu avec l'État de Hawaii et son département d'agriculture, dont une délégation est présente aujourd'hui, un accord de coopération sur un programme de lutte biologique, porteur d'espoir.

Il s'agit là d'un remarquable exemple de coopération régionale, où chacun, en fonction de ses moyens, apporte une contribution utile. La Polynésie française est représentée par le Docteur Jean-Yves MEYER, jeune chercheur polynésien, cheville ouvrière des programmes de lutte contre le Miconia, qui a effectué un post-doctorat à l'Université de Hawaii et assure le lien avec les chercheurs hawaiiens.

La conférence d'aujourd'hui initiée et organisée par le Ministère de la Recherche et le Centre ORSTOM de Tahiti, dont la coopération a été constante depuis 1988, participe également à la démarche d'ensemble du Gouvernement.

Mais l'effort de ce dernier doit être poursuivi et renforcé car le fléau est loin d'être maîtrisé. Récemment des plants de Miconia ont été découverts aux îles Marquises, laissant craindre le développement d'un nouveau foyer d'infestation si des mesures immédiates et vigoureuses ne sont pas prises par les autorités locales.

La prise de conscience de la gravité du phénomène ne doit pas en effet se limiter aux seules autorités du Gouvernement de la Polynésie française. Les communes à l'échelon local, ont un rôle prépondérant à jouer. Je souhaite qu'elles en soient convaincues et qu'elles s'en donnent les moyens. Les associations, comme les particuliers, doivent également participer à l'éradication d'un phénomène qui nous concerne tous, et ne peut être abandonné à la seule responsabilité du Territoire.

Le Ministère de la Recherche a demandé à la Délégation à la Recherche, qui assure un rôle pilote dans ce dossier, de réfléchir à la mise en place prochaine, d'un comité technique territorial de lutte contre le Miconia.

Ce comité aurait pour vocation de mieux sensibiliser l'ensemble des partenaires concernés, de favoriser leur implication financière ou humaine, de coordonner les actions et de proposer au gouvernement un plan d'action à moyen terme, chiffré. Son champ d'investigation ne devra exclure aucune orientation qu'il s'agisse de recherche, de campagnes d'arrachage, d'information et de formation, ou de dispositions réglementaires contraignantes.

Je ne doute pas à cet égard que les exposés scientifiques et techniques qui seront présentés au cours des premières journées du colloque sauront faire avancer utilement notre réflexion.

Mesdames et Messieurs, je veux terminer mon propos qui je l'espère n'aura pas été trop long, en remerciant nos partenaires qui ont permis l'organisation de cette manifestation.

A leur premier rang figurent le Ministère de la Recherche, la Délégation à la Recherche, le Centre ORSTOM de Tahiti et l'Institut Mathilde Frébault qui nous fait l'honneur de nous accueillir dans ses locaux.

Mesdames et Messieurs, je vous souhaite une bonne conférence et de fructueux débats.

Merci à vous.

OPENING ADDRESS BY THE PRESIDENT OF THE GOVERNMENT OF FRENCH POLYNESIA

read by **Dr. Patrick Tahiata HOWELL**
Minister of Health and Research

Ladies and Gentlemen,

The President of the Government, who cannot be among us today, has asked me to tell you how concerned by the Miconia problem the Government is.

In June 1992 the First Earth Summit, commonly known as the Rio Conference, brought to the public the notion of “biodiversity”, which had been known only by scientists until then.

Although the resolutions adopted on that occasion were not much followed by actual implementations, their merit was to lay emphasis on the importance to preserve biological diversity and on the threats it is confronted with.

The message of that conference was not to freeze the state of an ideal environment but rather to accompany its evolution with the constant concern of sustainable and controlled development.

The history of human progress is before all the history of harnessing nature, adapting its constraints to the development of human life.

Haven't our ancestors, on the first settlements of Polynesia, brought animal and plant species which did not exist, thus basically modifying the existing natural order ?

What is new is the outrageous power to mortgage the future through our present acts, which is made possible by our recent level of development.

Over a century, Humanity has released forces capable of having an impact on the major natural phenomena.

As an exemple, owing to the artificial production of carbon dioxide, the climate of the planet witnesses a significant green-house effect, which has reversed the natural trend towards glaciation.

50,000 animal or plant species also disappear each year because of an uncontrolled human activity, which then wastes the capital built over hundreds of millions of years of evolution.

Although awareness is slowly growing, such phenomena are still insufficiently known by the public and not properly assessed by the authorities, who do not actually realize the scope of the impact they are likely to have.

The submersion of low lands, the fragilization of agriculture, the climatic migrations, the breaks in ecologic equilibriums and the series of economic and social disorders they entail, are all up coming upheavals, the management of which should start today.

Biological invasions are less spectacular. Nevertheless they are a major risk to the environment, apt to alter the most fragile ecosystems.

On the international conference on "Introduced Plant Species" which was held in Norway in July 1996, experts stated that biological invasions by alien species will, in the next century, represent the most serious threat to biodiversity, even before habitat loss.

Their economic cost for the sole United States has been estimated at upwards of 100 billion dollars.

Many examples in history have shown that nature can sometimes restore threatened equilibriums by itself. Eradication programs against unwanted plants have proved successful in South Africa, New Zealand or Australia. But I know that the scientific community is mostly pessimistic, given the extent of the recent phenomena, and the little concern they arouse among the authorities. Yet monitoring such phenomena requires substantial coordinated and durable multidisciplinary means.

The major invasion of the Mediterranean Sea by the sea weed *Caulerpa taxifolia* since 1984 can unfortunately be considered as a model concerning both its scientific interest and the little concern of the authorities.

In French Polynesia, the controlled management of natural heritage is perhaps a matter which is even more sensitive than anywhere else.

The area of the Territory is small, its insular ecosystem fragile, and last but not least, its population is growing very sharply. Most of its resources come from a still generous environment.

You know that French Polynesia's main own revenues come from tourism, black pearls and fisheries, which are sectors of the future, induce growth and a greater economic independence.

The craze for natural exotic substances or ones having special virtues is also opening substantial opportunities for the Polynesian economy. Noni (*Morinda citrifolia*) juice, Kava (*Piper methysticum*), Tamanu (*Calophyllum inophyllum*) Oil and many other essential oils, may, alongside with vanilla, find a privileged niche in the export markets of French Polynesia, as long as the quality requirements imposed by international markets are met.

But all these prospects of development will become concrete only under a controlled management of the natural resources which make them possible.

The nature protection organization "Conservation International" unfortunately classifies Polynesia among the 17 hot spots of the globe which face the most serious attacks to biodiversity.

The history of biological invasions in French Polynesia is old and rich. Far from being exhaustive I will give the following examples. Concerning the recent introductions which are particularly noxious: the Beach Nono (*Culicoïdes belkini*) imported in 1959 from Fiji, and which haunts the beaches of the Leeward and Tuamotu Islands is detrimental to tourism activities. There is also the common Myna (*Acridotheres tristis*) which is swarming in the Society Islands. I will also quote the carnivorous snail *Euglandina rosea* introduced in 1974 from Guam, and which has already caused the extinction of 9 species of *Partula* in Moorea and many other species in the Society islands.

Miconia calvescens, which is the subject of our conference, was introduced in 1937 as an ornamental plant. As it escaped from the botanical garden of Papeari for which it was intended, it started its slow but regular invasion of wet mountain areas.

I will let the scientific lecturers tell us about the level of proliferation it has reached, and which is particularly alarming on the island of Tahiti, and about its catastrophic consequences on local flora.

As for me, I would like to illustrate what I have just said by stressing the serious risks entailed by the rampant expansion of Miconia on the tourism sector, which depends on the beauty of the landscape, on agriculture and on the quality of our environment, which is one of the assets of French Polynesia.

As from 1988, the cooperation between the government of the Territory and ORSTOM has resulted in the establishment of the first research programs towards a better identification of the phenomenon.

Removal campaigns have regularly been carried out since 1992 in the Leeward Islands by the agents of the Rural Development Service, with the essential and never failing support of the French Army.

More recently, in the framework of the Development Contract, the Government of French Polynesia entered into a hopeful cooperative agreement on a biocontrol program with the Agriculture Department of the State of Hawaii, of which a delegation is present today.

This is an outstanding example of regional cooperation, where each party, according to its means, brings a useful contribution. French Polynesia is represented by Dr. Jean-Yves MEYER, a young Polynesian research scientist, the mainspring of the Miconia control programs and who has attended the University of Hawaii as a visiting scholar and acts as the link with the Hawaiian researchers.

The Conference of today, which was initiated by the Delegation for Research and the ORSTOM Center of Tahiti, whose cooperation has been constant since 1988, also falls within the overall scheme of the government.

But its effort must be maintained and intensified because this plague is far from being controlled. Miconia young plants have recently been discovered in the Marquesas Islands. It is feared that a new infestation center could develop if immediate and effective steps are not taken by local authorities.

Indeed awareness must not be limited to the sole authorities of the Government of French Polynesia. At the local level, municipalities also have a major role to play. I wish they become convinced of it and get the means for action. Associations and individuals also have to take part in the eradication of a phenomenon which affects us all, and which cannot be left to the sole responsibilty of the Territory.

As for me, I have asked the Delegation for Research, which has a leading role in that matter, to think about the establishment in the near future of a territorial technical committee for Miconia control.

That committee would seek to better arouse awareness among the relevant partners, develop their financial or human involvement, coordinate actions and make proposals to the government regarding a plan of action in the medium term, with numbers. Its ambit shall exclude no sector, be it research, tearing-off campaigns, information and training sessions, or binding regulatory provisions.

I have no doubt that that the scientifc and technical presentations that will be presented during the first days of this conference will provide useful inputs.

Ladies and Gentlemen, I would like now to end my speech, which I hope will not have been too long, by thanking our partners who contributed to the organization of this event.

At the top of the list is the Delegation for Research, the ORSTOM Center of Tahiti and the Mathilde-Frébault Institute which is hosting us in its premises.

Ladies and Gentlemen, I wish you a good conference and fruitful debates.

SESSION 1

ÉTUDE ET LUTTE CONTRE *MICONIA CALVESCEN*
EN POLYNÉSIE FRANÇAISE

LES PLANTES VASCULAIRES INDIGÈNES DE LA SOCIÉTÉ : SITUATION ACTUELLE, MENACES ET PERSPECTIVES DE SAUVEGARDE

THE NATIVE VACULAR PLANTS OF THE SOCIETY ISLANDS: CURRENT SITUATION, THREATS AND CONSERVATION PROSPECTS

JACQUES FLORENCE

Antenne ORSTOM/Muséum national d'Histoire naturelle, Laboratoire de Phanérogamie, 16 rue Buffon, 75005 Paris, FRANCE.

Les données discutées ici s'appuient sur un travail de prospections sur le terrain effectué durant un programme d'inventaire mené au Centre ORSTOM de Tahiti entre 1982 et 1994, ainsi que de compilations de données bibliographiques et d'études de spécimens végétaux dans les grands herbiers internationaux, le tout intégré dans une banque de données botaniques "Nadeaud". Cette étude met en évidence la place prédominante des îles de la Société dans l'ensemble des cinq archipels. Ainsi, sur environ 500 espèces endémiques de Polynésie française, la Société en compte 250 avec un taux d'endémisme de 43 %. Tahiti, en raison de sa taille, de son altitude et de la diversité de ses groupements végétaux, compte environ 107 espèces endémiques sur une flore indigène comptant environ 500 espèces.

Le statut de conservation de ces espèces dépend de nombreux facteurs : si la situation globale de la Polynésie française est déjà préoccupante (21 espèces, soit 4% du total, sont considérées comme éteintes), 110 des 500 espèces endémiques appartiennent aux catégories les plus sensibles définies par l'UICN. Mais cette situation recouvre des disparités réelles et il conviendrait de se pencher sur certaines urgences. Ainsi le couple Tahiti - *Miconia calvescens* arrive en tête : 33 sur 47, soit environ 70% des espèces endémiques de la Société et appartenant aux catégories les plus vulnérables sont menacées par l'extension de *M.c.* ou d'autres pestes ; 41 sur 58, soit environ 70% des espèces endémiques de la Société et appartenant elles aussi aux catégories les plus sensibles, mériteraient des mesures immédiates de protection. De telles mesures pourraient s'appliquer soit à des espèces-phare ou des espèces-test choisies à partir de la connaissance de leur statut actuel, ou au contraire, on s'attachera à des mesures prises dans des communautés végétales diversifiées et menacées à brève échéance par l'extension de *M.c.*

The data discussed here are based on field surveys conducted during an inventory program at the Centre ORSTOM of Tahiti between 1982 and 1994, on compilations of bibliographic data, and on studies of plant specimens located in the main international herbaria. All these data are incorporated in a plant data bank called "Nadeaud". This study confirms the predominance of the Society Islands among the five archipelagoes. Hence, among about 500 species endemic to French Polynesia, the Society Islands have 250 and a rate of endemism of 43%. Tahiti, because of its size, its elevation and the diversity of its plant communities, has about 107 endemic species of the 500 species that form its native flora.

The conservation status of those species depends on several factors. The situation in French Polynesia is already worrying (21 species, i.e. 4% of the total, are considered to be extinct), a further 110 of the 560 endemic species belong to the most endangered categories defined by IUCN. But these numbers mask real disparities and we need to focus on certain urgent problems. The presence of Miconia calvescens *in Tahiti is among the leaders. 33 of the 47 species, i.e. about 70% of the species endemic to the Society Islands, belong to the most vulnerable categories and are threatened by the expansion of* M.c. *or other plant pests. 41 on the 58, i.e. about 70% of the species endemic to the Society Islands also belonging to these most endangered categories, need immediate protection measures. Such measures could be applied to star-species or test-species selected because of our understanding of their present status. Contrarily, we should focus on diverse plant communities threatened in the short-term by the expansion of* M.c.

EPIDEMIOLOGY OF THE INVASION BY *MICONIA CALVESCENS* AND REASONS FOR A SPECTACULAR SUCCESS

ÉPIDÉMIOLOGIE DE L'INVASION PAR MICONIA CALVESCENS *ET RAISONS D'UN SUCCÈS SPECTACULAIRE*

JEAN-YVES MEYER[1, 2]

[1]Délégation à la Recherche, B.P. 20981 Papeete, Tahiti, POLYNÉSIE FRANÇAISE.
[2]Cooperative National Park Resource Studies Unit, Botany Department, University of Hawai'i at Manoa, Honolulu, HAWAI'I (USA).

Miconia calvescens is a small tree native to rainforests of tropical America where it is uncommon. First described around 1850, it was introduced to European tropical greenhouses then distributed to tropical botanical gardens all over the world because of its horticultural success. *M.c.* was introduced as an ornamental plant in the Society Islands and the Hawaiian Islands and in 25-35 years became a dominant invasive plant in both archipelagoes. Small populations were recently discovered in the Marquesas Islands (Nuku Hiva and Fatu Iva) in 1997. *M.c.* is also naturalized in private gardens of New Caledonia and Grenada (West Indies), in tropical forests of Sri Lanka, and in the Queensland region in Australia. The survey of the epidemiology of invasion in Tahiti shows that *M.c.*'s extension was slow but continuous since its introduction in 1937. Hurricanes of 1982-83 played more a role of "revealer" rather than of "detonator" of the invasion. The lag phase observed between the introduction date and the observation of dense populations may be explained by the generation time of *M.c.*. Several hypothesis may explain the spectacular success of *M.c.*: (1) the characteristics of the invaded area; (2) the plant's bio-ecological characteristics; (3) the "facilitation phenomenon" and the "opportunities". *M.c.* provides an interesting study-case for understanding of biological invasions in islands, and a catastrophic example of an alien invasive species that threatens the biodiversity of islands.

Miconia calvescens *est un petit arbre originaire des forêts humides d'Amérique tropicale où il est peu commun. Décrit vers 1850, il a été introduit dans les serres tropicales d'Europe puis distribué dans les jardins botaniques tropicaux du monde entier en raison d'un grand succès horticole. Introduit comme plante ornementale dans les îles de la Société et dans les îles Hawai'i, M.c. est devenu en 25-35 ans une plante envahissante majeure dans ces 2 archipels. De petites populations ont été récemment découvertes aux îles Marquises (Nuku Hiva et Fatu Iva) en 1997. M.c. s'est également naturalisé dans des jardins privés en Nouvelle-Calédonie et à la Grenade (Antilles), dans les forêts tropicales du Sri Lanka et de la région du Queensland en Australie. Le suivi de l'épidémiologie de l'invasion à Tahiti montre que l'extension de M.c. a été lente mais continue depuis sa première introduction en 1937 ; les cyclones de 1982-83 ont joué un rôle de "révélateur" plutôt qu'un "détonateur" de l'invasion ; la phase de latence observée entre la date d'introduction et l'observation de couverts denses peut être expliquée par le temps de génération de M.c. Plusieurs hypothèses peuvent expliquer le succès spectaculaire de M.c. : (1) les caractéristiques de la zone envahie ; (2) les caractéristiques bio-écologiques de la plante ; (3) le "phénomène de facilitation" et les "opportunités". M.c. constitue à la fois un modèle d'étude intéressant pour comprendre les processus d'invasion biologique dans les îles et un exemple catastrophique d'une espèce étrangère envahissante menaçant la biodiversité des îles.*

Epidemiology is commonly defined as "a branch of medical science that deals with incidence, distribution and control of a disease in a population" (Woolf, 1977). By analogy, biological invasions by alien animals or plants might be compared to infectious diseases caused by pathogens. First of all, invaders like epidemic agents show three main stages during the invasion process (Di Castri, 1989; Shigesada and Kawasaki, 1997):

(1) initial establishment, or colonization, in a non-infected region usually by small number of individuals or even a single propagule.
(2) persistence, or naturalization: the species become established in the wild with the ability to reproduce by sexual or vegetative means without assistance of man.
(3) spatial spread, or extension: the species expands its range, altering the structure, composition and processes of ecosystems with significant damage to native biotas.

Secondly, knowledge of the origin of an infectious agent (the native range of an invader), its nature (the biology and ecology of an invader), its spatial spread (the population dynamics of an invader) and the symptoms of the disease (the conservation impacts of an invader), as well as the reasons of success, is important to fully understand the epidemic (the process of biological invasion) and to elaborate efficient curative means (control methods). Finally, prevention of invasion, as for diseases, is often the only defense (McDonald, 1997).

M.c., sometimes called "the green cancer" in French Polynesia or "the purple plague" in the Hawaiian Islands in public information literature, is considered by scientists to be the worst plant pest in these two Polynesian archipelagoes and potentially the most damaging weed of rainforests of Pacific islands (Meyer, 1996; Medeiros *et al.*, 1997). The biological invasion by *M.c.* is perhaps one of "the most incredible and spectacular cases of a noxious plant invasion" in island terrestrial ecosystems (R. Petocz, Environmental Consultant for SREP, in a letter dated November 1993 to Jeffrey A. McNeely, Biodiversity Officer at IUCN, after his visit to Tahiti). For conservation biologists and natural areas managers, *M.c.* also represents a dramatic example of the need for active management of long-term threats that cause massive losses in biological diversity (Loope and Medeiros, 1995).

In this paper, I have compiled the available information on *M.c.* in its native range, its discovery and cultivation as an ornamental plant, its current status and distribution worldwide, and its expansion in French Polynesia, especially the dynamics of its extension in Tahiti. This review enables the examination of different hypotheses explaining the striking success of this invasive species. Information already published in previous comprehensive studies (Meyer 1994; 1996) is discussed and supplemented with many unpublished documents and updated data.

ORIGIN

As with many alien plants that subsequently became serious plant pests in new areas where they have been introduced accidentally or intentionally by man, very little information is known about the natural life-history characteristics of *M.c.* in its native range. As far as we know, there is no biological or ecological study conducted on this species in any country where it is native. This may be explained by the fact that there are about 1000 species of *Miconia* throughout tropical America (Wurdack, 1980) and because *M.c.* has evoked no real ecological or economical interest to date. Other *Miconia* species are well-known in their native range by local people for their traditional uses (such as *M. longistyla* for timber in Panama, *M. macrophylla* for its edible fruits, *M. cinnamomifolia* for its fruits used to make a yellow dye in the West Indies, *M. agrestis* in Peru and Guyana whose fruits might contain an anti-biliary substance, or *M. fothergilla* whose sap is applied to stings to relieve pain (Baillon, 1880)) or by scientists for their bio-ecological particularities (such as *M. argentea*, a dominant pioneer in large gaps on Barro Colorado Island in Panama (Brokaw 1985) or the seedling establishment of *M. albicans* after fire in pine savanna of Belize (Miyanishi and Kellman, 1986)).

Most information concerning *M.c.* in its native range comes from taxonomic descriptions of the family Melastomataceae published in early monographies (mostly written during the

19th century) or in relatively recent floras of the American tropics, when the Melastome family, one of the largest families in the world with about 4000 species and 200 genera (Cronquist, 1981), is included. Melastomataceae, however, have not been treated in the "Flora Neotropica" yet. De Candolle (1828), Triana (1871), Grisebach (1879), von Martius (1887) and Cogniaux (1891) made the first descriptions of *M.c.* and gave some locations of this species in its native range without giving any information on the life-history traits of the species itself (see ref. in Meyer,1994). A few comments on *M.c.* can be found in studies dealing with the family Melastomataceae or with the genus *Miconia* in selected regions of tropical America, such as the Yucatan Peninsula in Mexico (Gleason, 1940) or the region of Rio de Janeiro, Brazil (Baumgratz, 1980). Herbarium specimens are certainly one of the best source of information, apart from their fundamental interest in taxonomy and systematic, especially when the label written by the plant collector describes the exact location, the forest type, the surrounding plant community and some characteristics of the habit of the plant.

A compilation of all the documents on *M.c.* in its native range (**Table 1**) demonstrate that:

(1) the species has a wide distribution from southern Mexico to northern of Argentina;
(2) the discolorous form, with purple-blue leaves underneath (also found in cultivation), appears to be restricted to Central America (Meyer, 1994; 1996). However, in Costa Rica, it is observed that the leaves are "purple on the underside of young plant but as the plant matures, the undersides of the leave turn green" (R. Burkhart, pers. comm., 1993);
(3) it is a small tree up to 15 m high;
(4) it is found in tropical rainforests or wet forests (where the mean annual rainfall and temperature are respectively > 2000 mm and > 22º C (Budowski, 1965));
(5) it is found in lowland to montane forests, up to 1800 m elevation;
(6) it grows in disturbed or second-growth forests, in semi-open areas (such as small gaps, forest edges, stream banks, trail sides) and more rarely in the understory of dense primary forest. The exploratory entomologist R. Burkhart (formerly at the Hawaii Department of Agriculture) observed *M.c.* growing in Costa Rico at about 700 m elevation, mainly "along streams in forested areas" or "at edge of forest" (Burkhart, 1993-1994). *M.c.* seems to behave as "an early successional tree species of wet thickets and dense mixed forest, colonizing small light gaps" (R. Burkhart in Medeiros *et al.*, 1997).

According to botanists who have done extensive field work and/or have collected the species in the American tropics, *M.c.* "is not a particularly common species" (F. Almeda, pers. comm., 1992) and "never [...] occurs in monospecific formations" (F. Almeda, in a letter dated November 1988 to P. Birnbaum). P. Morat, the current director of the Laboratoire de Phanérogamie of the Natural History Museum of Paris emphasized that, with only some 40 herbarium specimens present in Paris, this species has been little collected and concluded that "in its native countries, it is obviously a very banal species" (letter dated September 1988 to J. Florence).

Table. 1. Location, habitat and habit of *M.c.* in its native range in tropical America (from North to South)

Native country	Habitat	Elevation range	Max. height	Source
MEXICO	tropical rainforest, montane rainforest	250-1170 m	12 m	Herbarium specimens
GUATEMALA	tropical rainforest, dense forest, mixed and secondary forest, exposed site	150-1400 m	10 m	Herbarium specimens
	moist or wet thickets, dense mixed forest	< 1800 m	12 m	Flora of Guatemala (Stanley and Williams, 1963)
BRITISH HONDURAS	primary forest, old second growth woods	45-620 m	10 m	Herbarium specimens
	wet forests at low elevation			Melastomataceae of the Yucatan Peninsula (Gleason, 1940)
NICARAGUA	rainforest	-	-	Herbarium specimens
COSTA RICA	rainforest, premontane rainforest, wet second growth forest	635-900 m	15 m	Herbarium specimens
PANAMA		-	10 m	Flora of Panama (Woodson and Schery, 1958)
		<1000-2000 m	-	Flora of Panama (d'Arcy, 1987)
COLOMBIA	secondary forest	1200 m	4 m	Herbarium specimens
		-	-	Cogniaux (1891)
EQUADOR	dense forest, trail side	400	4 m	Herbarium specimens
		300-1800 m	16 m	Flora of Equator (Harling and Sparre, 1980)
PERU	dense lowland rainforest, montane rainforest, cloudforest, disturbed rainforest, inundated forest, river bank, along trail, in moderate or dense shade	100-1500 m	15 m	Herbarium specimens
		-	10 m	Flora of Peru (McBride, 1941)
BOLIVIA	wet thickets	1500 m	8 m	Herbarium specimens
		-	-	Cogniaux (1891), Woodson (1958), d'Arcy (1987)
BRAZIL	cut-over woods, galery-forest, forest edge, river bank	300 m	8 m	Herbarium specimens
	sciaphile or semi-heliophile	-	6 m	Triana (1971), Cogniaux (1891), Baumgratz (1980)
PARAGUAY		-	6 m	Herbarium specimens
		-	-	Cogniaux (1891)
ARGENTINA		-	-	Herbarium specimens
		-	-	Grisebach (1879), Cogniaux (1891)

DISCOVERY AND CULTIVATION

M.c. was first discovered by Auguste Ghiesbrecht, a Belgian botanical explorer (or "naturaliste-voyageur") who lived in Mexico for 10 years. The discovery occured probably between 1850-1855, during A. Ghiesbrecht's second expedition to the Chiapas district, S. Mexico (Morren, 1849). He found the species in "the wet and shady forests that surrounded the mysterious ruins of Palenque" (Linden, 1858) and sent it to his botanist collegue and friend Jules, J. Linden, a famous plant dealer at Luxemburg between 1845 and 1852 and the director of the Jardin Royal de Zoologie et d'Horticulture in Brussels between 1852 and 1861 (Staflew and Cowan, 1981). They had explored together, collecting many plants, in Brazil in 1835 and in Mexico (especially the districts of Tabasco, Xalapa, Chiapas) between 1838 and 1840, along with the Belgian botanist Nicholas Funck (Linden and Planchon, 1867).

Linden (1858) first named the species *Cyanophyllum magnificum* because of its large magnificent leaves with purple-blue undersides and exhibited it in 1857 in London, the Paris Society of Horticulture exposition, and the Horticultural Festival of Berlin. The first morphological description of *Cyanophyllum magnificum* was written in August 1857 by Koch, the editor of the German horticultural bulletin "Berliner Allgemeine Gartenzeitung". The first picture of this plant (drawn by Riocreux) was published in 1859 in the "Revue Horticole" (**Fig. 1**), a French journal of practical horticulture (Groenland, 1859). The species is described as "a jewel of the plant kingdom" (Linden, 1858) that "aroused the admiration of all lovers of plant wonders" (Groenland, 1859). It was mentioned later on as "one of the best and most striking of all conservatory foliage subject" in the authoritative "Cyclopedia of American Horticulture" (Bailey, 1930) and as one of the most magnificent hothouse plants in the German horticultural journal "Pareys Blümengartnerei (1932)" (B. E. Leuenberger, pers. comm., 1993). Since its discovery, this very attractive ornamental plant has been propagated in the greenhouses of many botanical gardens in Europe and distributed to many tropical gardens worldwide where it was cultivated (**Table 2**) under the name *Miconia magnifica* Triana (Wurdack, 1971) or under the common name "velvet tree" (Graf, 1986) because of the small stellate hairs found on young stems and leaves (Wurdack, 1986). A form with more bronzy foliage and flat leaves rather than arched, and known in garden as *Miconia velutina* Linden & Rodigas does not differ sufficiently to warrant botanical separation (Wurdack, *op. cit.*) but may be worth distinguishing horticulturally as *M.c. velutina* (Everett, 1981).

Fig. 1. First drawing of *M.c.* in cultivation (syn. *Cyanophyllum magnificum* Lind. or *Miconia magnifica* Triana in horticulture) published in 1859 (*in* Groenland, 1959).

Information on the cultural practices of this species found in horticultural literature are noteworthy. According to the "Gardener's Chronicle" (Anonymous, 1930), "*Miconia magnifica* delights in a high temperature [...], it cannot be grown too near the glass, its leaves are thin in texture, and if not shaded when the sun comes directly upon them with any force, they are liable to be scorched [...], plenty of water should be given at the roots". In "Tropical and Subtropical Gardening", the author advised to "water copiously while in active growth [...], watch for leaf-eater, scale and mealy bugs" (Oakman, 1975).

Horticultural recommendations teach us some important biological characteristics of *M.c.*: (1) the species needs a lot of humidity and a warm temperature; (2) direct sunlight must be avoided (3) it reproduces vegetatively from cuttings ("strikes easily from hardwood or soft tip cutting", Oakman, *op. cit.)* (4) it is often attacked by insects in greenhouses. It is ironic in light of its now well-documented invasive tendencies that horticulturists consider this species to be very difficult to grow ("unfortunately, it is not very often met in these days, possible owing to the fact that it is not the easiest of plants to grow successfully" (Anonymous,1930) "contrarily to other Melastomataceae, the species of *Miconia* have difficulties to implant outside their native range. When cultivated in hot-houses, they required a lot of care" (De Wit, 1965)). Nowadays, *M.c.* is still cited and recommended for planting in the main horticultural plants books such as "Exotica" (Graf, 1974), "Hortus Third" (Bailey and Bailey, 1976), "Tropica" (Graf, 1986) or "Tropical Planting and Gardening" (McMillan *et al.*, 1991).

Table 2. Cultivation sites of *M.c.* as an ornamental plant (outside tropical America)

Country of Introduction	Site of introduction	Dates of cultivation	Source
ALGERIA	Jardin d'Essai du Hamma	1952	Carra and Gueit (1952)
BELGIUM	Jardin Royal de Zoologie et d'Horticulture de Bruxelles	1857-1907	F. Billiet, pers. comm. 1993
GERMANY	Botanisher Garten München	until 1943	A. Kress, pers. comm., 1993
INDONESIA	Bogor Botanical Garden	1950-1960	O. Dharmaputra and I. Suhirman, pers. comm., 1992
THE NETHERLANDS	Rijksuniversiteit, Utrecht	1978	B. J. Ter Welle, pers. comm., 1992
THE PHILIPPINES	Los Banos, near Manilla	still in cultivation	R. Petocz, pers. comm., 1993
UNITED KINGDOM	Royal Botanic Garden, Edinburgh	until 1969	J. D. Main, pers comm., 1993
	Liverpool Botanic Garden, Calderstones Park	no longer	*id.*
USA	Fairchild Tropical Botanical Garden, Miami	no longer (from seeds collected in Mexico in 1967)	C. Hubbush, pers. comm., 1993
	United States National Arboretum, Washington DC	1971	*id.*
ZAIRE	Jardin Botanique de Kisantu	1972	Pauwels (1972)

SITES OF NATURALIZATION

Although *M.c.* has not succeeded in naturalizing in some tropical countries where it has been planted and cultivated as a garden ornamental, such as in the Bogor Botanical Garden (O. Dharmaputra and I. Suhirman, pers. comm., 1992), it has become established in the surrounding vegetation in others. Indeed, *M.c.* is able to self-reproduce and to form viable populations from a single individual (Meyer, 1994; Meyer, in press). The tropical regions where *M.c.* is naturalized show a pronounced climatic similarity with the native country of tropical America, with an annual rainfall above 2000 mm (**Table 3**). However, in new areas of introduction where naturalization occurs, *M.c.* is not consistent in its tendency to invade.

Table 3. Sites of naturalization of *M.c.*

Country of introduction	Site of introduction	Date of introduction	Elevation range (m)	Rainfall (mm/yr)	Source
AUSTRALIA	Flecker Botanical Garden, Cairns	1968			M. Bryannah, pers. comm., 1996
	Townsville Botanic Gardens	1963			S. Csurhes, pers. comm., 1997
	Melbourne Botanical Garden	before 1980			*id.*
GRENADA	St George	around 1970	300	1520-2540	P. Cazin, pers. comm., 1995
JAMAICA	Castleton Garden, St Mary	before 1970	244	2030	Wurdack 1971
NEW CALEDONIA	Yahoué valley, Nouméa	1970's	500-600	1700-2000	R. Lavoix, pers. comm., 1993, 1994; J.-C. Pintaud, pers. comm., 1995, 1996
SRI LANKA	Botanical Gardens of Peradeniya	1888	480	3020	A. H. M. Jayasuryia, pers. comm., 1993
	Kandy district		700-900	5400	*id.*

New Caledonia--The only known population of *M.c.* in New Caledonia is found in a private botanical garden located above the town of Nouméa above the Yaouhé Valley on the slopes of the Mount Koghi (summit at 1061 m elevation). This botanical garden was created in 1957 by Lucien Lavoix, "an excellent horticulturist as well as a botanist" (Barrau, 1966) who introduced many alien species as ornamental or cultivated plants. According to his son Raymond Lavoix who now owns the garden, *M.c.* was introduced 20 years ago probably from Tahiti (R. Lavoix, pers. comm., 1993) and "the population is not very abundant and propagates very slowly" (R. Lavoix, per. comm., 1994). He estimated several years ago the *M.c.* population to be 100 individuals, the biggest one being 4-5 m tall and fruiting (R. Lavoix, pers. comm., 1993). The current population was checked in 1996 by J.-C. Pintaud, a botanist of ORSTOM-Nouméa: he found a single mature tree and several saplings between 1-2 m tall, located around the mother tree. However, the 800 ha of the botanical garden have not been carefully prospected by J.-C. Pintaud, and R. Lavoix recognized having sold plants in his nursery before being aware that the species is a pest plant. The habitat where *M.c.* is naturalized is a disturbed forest with bamboos and palms at about 500-600 m elevation (J.-C. Pintaud, pers. comm., 1996). Soil is composed of schistose or ultrabasic rocks and climate is wet, with mean annual rainfall between 1700 and 2000 mm (Sautter, 1981). The particular nature of the soil (ultrabasic rocks are very poor in mineral elements such as N and K, and a high concentration of Mg and toxic heavy metals such as Ni, Co and

Cr) may constitute a major obstacle to the establishment of *M.c.* and other alien plant species in this southern part of New Caledonia.

Jamaica--Although *M.c.* is not cited among the 24 species of *Miconia* present in Jamaica (Adams, 1972), the species is naturalized and common at Castleton Garden and flowering specimens were collected in 1970 (Wurdack, 1971). The botanical garden is located at 244 m elevation (Heywood *et al.*, 1990) in the region of St. Mary on the North side of the island where the surrounding vegetation is mainly cultivated pastures and second-growth scrub (Asprey and Robbins, 1953). Soil consists of limestone and annual precipitation in the garden is about 2030 mm (Heywood, *op. cit.*). In a letter addressed to A. Chonin of the Service de l'Économie Rurale (French Polynesian Department of Agriculture) and dated August 1979, J. J. Wurdack stated that *M.c.* requires "high humidity and more-or-less acid soil". This may explain why the species is "naturalized only to a limited extent in Jamaica where areas of acid soils are limited". Unfortunately, my attempts since 1992 to contact botanists in Jamaica who could provide some information on *M.c.* were not successful and the degree of naturalization is currently not known.

Grenada--The only known population of *M.c.* in the island of Grenada (Lesser Antilles) is above the town of St. George at about 300 m elevation below the Grand Étang Forest Reserve (P. Cazin, pers. comm., 1995). Rainfall ranges from 1520 and 2540 mm and soils are "lithosols and red earths" according to the characteristics of major agro-ecological zones of Grenada (unpub. data). The plant was introduced by John Griswick, an artist and ornamental plants enthusiast living in the island for 20 years; he received a specimen of *M.c.* from Sri Lanka 15 years ago and cultivated a single plant in his private property. The plant mature and reproduced profusely, then died in 1980-90 (P. Cazin, pers. comm., 1995). According to P. Cazin, an agricultural engineer, there was a single new reproductive tree growing in 1995 about 4 m tall and 15 cm basal diameter, originating from a seedling of the first tree. Many seedlings have been removed by the owner and the few seedlings left were found on the ground near the parent tree. Most of them were heavily attacked by unidentified leaf-eaters (P. Cazin, pers. comm., 1995). The Lesser Antilles has about 20 native species of *Miconia* (Howard, 1989). None of them are invasive probably the result of natural enemies that keep their populations in check.

Sri Lanka--*M.c.* was introduced to the Royal Botanical Garden, Peradeniya, from Mexico in 1888 (A.H.M. Jayasuriya, pers. comm., 1993). Despite a century of cultivation, naturalization has not taken place within the garden proper whose elevation is about 480 m and annual precipitation 3020 mm (Heywood *et al.*, 1990). The species has become naturalized 40 km south of the garden, however, in a wetter area in higher elevation wastelands near Nawalapitiya and Ginigathena, Kandy district, Central Province, where mean annual rainfall and temperature are respectively 5400 mm and 21º C. (A.H.M. Jayasuriya, pers. comm., 1993). *M.c.* is found in disturbed natural vegetation between 700-900 m elevation along rivers and trails. According to A.H.M. Jayasuriya, a botanist and curator of the National Herbarium of Sri Lanka, the plant "is still grown in botanical gardens and occasionally in some home gardens [...] but is not a perturber of vegetation communities in Sri Lanka" (letter dated January 1989 to P. Birnbaum), "there are small scale naturalizations in one or two areas but the species has not established as a weed" (A.H.M. Jayasuriya, pers. comm., 1993). *M.c.* populations are small and seem not to be extensive. The forest structure in Sri-Lanka, with a canopy reaching 30-40 m tall whereas it doesn't exceed 10-20 meters in Pacific tropical oceanic islands, could explain the difference in the invasion success of *M.c.* (Meyer, 1994; Meyer, in press).

Australia--The introduction of *M.c.* as a garden ornamental was first reported in the Flecker Botanical Garden in Cairns (North Queensland) and a few other gardens (Humphries and Stanton, 1992). The species is known to have been introduced in the Flecker Botanical Garden in 1968, the original source of the specimen was a plant supplier, Limberlost Nursery, also located in Cairns (M. Bryannah, pers. comm., 1996). In 1996, "a small number of specimens" were observed in the Botanical Garden, some of them were fruiting. According to S. Csurhes, Exotic Species Officer at the Land Protection Branch, *M.c.* was also introduced in 1963 in Townsville Botanical Gardens, in Melbourne Botanical Garden before 1980 and in private nurseries (S. Csurhes, pers. comm., 1997). It has escaped and is now naturalized in the tropical region of North Queensland (Cairns, El Arish and Mossman) where it is considered to have a great invasive potential (Csurhes, this volume).

SITES OF INVASION

Since its introduction as an ornamental plant in the Society Islands (Moorea, Raiatea, Tahaa, Tahiti) and in the Hawaiian Islands (Hawai`i, Kaua`i, Maui, O`ahu), *M.c.* has become a dominant invasive species in these two Polynesian archipelagoes. The species thrives from nearly sea level up to 1300 m elevation in disturbed and native wet forests where the mean annual rainfall is usually above 2000 mm (**Table 4, Fig. 2**). Islands where *M.c.* has been introduced earlier show more extensive invasion except in the island of O`ahu where a few seedlings have been discovered despite an old introduction, such as in the Wahiawa Botanical Garden (Conant and Nagai, this volume). The low rainfall (about 1500 mm/yr) may explain the relative failure of this species that might be considered growing in suboptimal ecological conditions.

The Society Islands--*M.c.* was first introduced to Tahiti (Windward Group) in 1937 by Harrison W. Smith in his private botanical garden (nowadays called the "Harrison Smith Botanical Garden") located in the Papeari district; its introduction in the neighboring island of Moorea, about 20 km N-W of Tahiti, is not precisely known but the plant was already noticed in the early 1970's on mountain trails (Meyer 1994; 1996). A single tree was noted by J. Florence in the Opunohu valley in 1983 (letter dated April 1983 to the Chief of the Forestry Section, Service de l'Économie Rurale).

M.c. was introduced in the island Raiatea (Leeward Group) between 1955-1958, by Jacques Rentier, former chief of the Service de l'Économie Rurale at that time, in the private garden owned by Mme Lenormand and located in the low valley of Uturaerae (R. Amiot, pers. comm. to the journalist J.-P. Besse in June 1997). In the 1970's and the 1980's, seeds were accidentally introduced to the Tetooroa and the Faaroa valleys respectively with soil in plant pots from Tahiti (Meyer 1996; Meyer and Malet 1997).

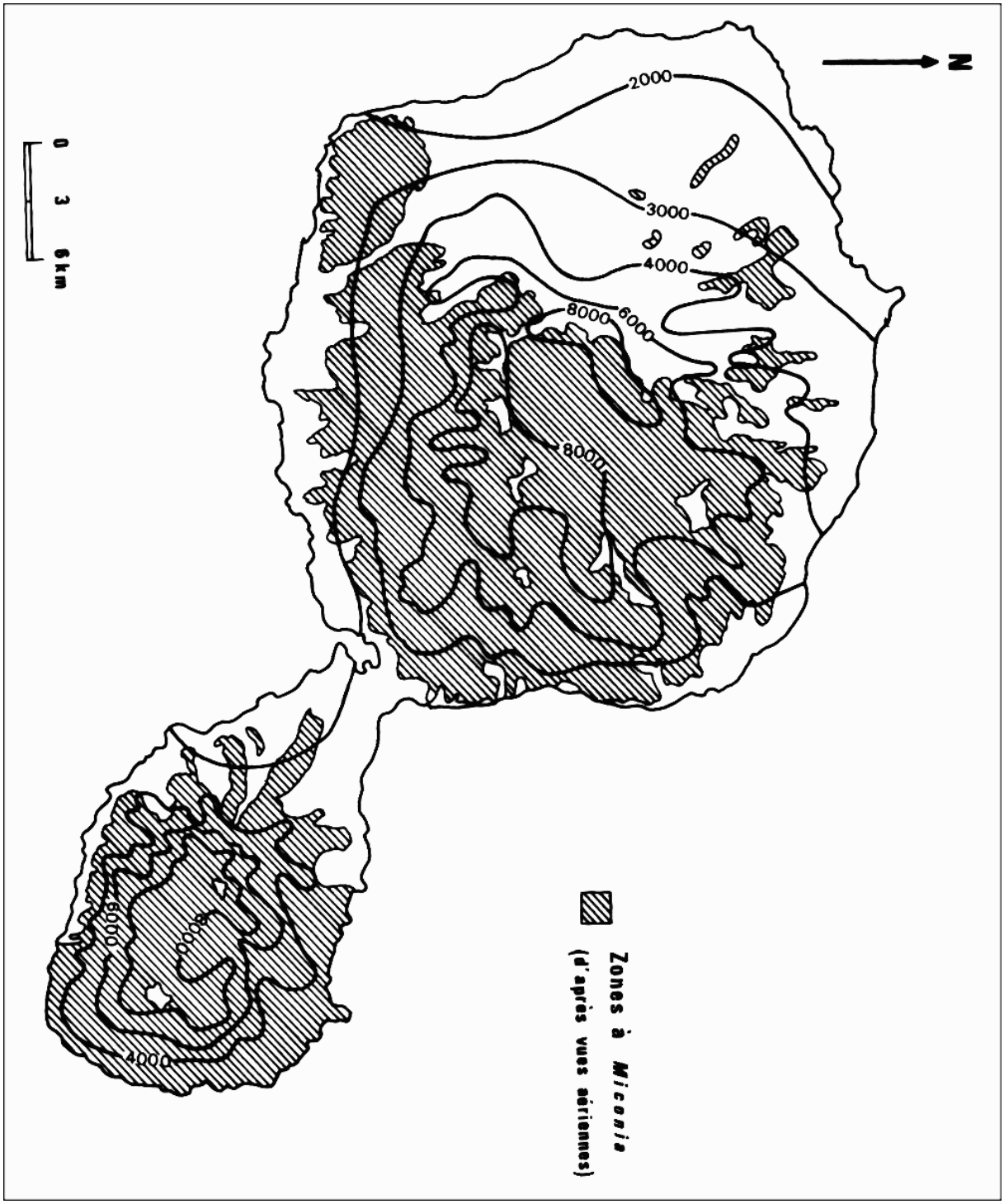
M.c. was introduced in Tahaa in the early 1980's, probably with infected soil stuck on the wheels of bulldozers used for road-construction and is now naturalized in a single valley. On the island of Huahine, seedlings of *M.c.* were observed in 1995 in the village of Fare, growing on a soil dump originating from Tahiti, and quickly eliminated (Meyer and Malet, 1997).

Finally, a few seedlings were found on the uninhabited island of Mehetia, on a pile of soil and rock brought by Tahitians for the building of a small house (M. Wong, pers. comm., 1997).

Table 4. Sites of invasion by *M.c.*

ISLAND	Site of introduction	Date of introduction	Elevation (m)	Rainfall (mm/yr)	Source
FRENCH POLYNESIA					
Society Islands					
TAHITI	Harrison Smith Botanical Garden, Papeari	1937	10	> 2000	H. W. Smith, personal notes
	65-70% of the island (70 000-80 000 ha)		10-1300	> 2000	Birnbaum, 1991 ; Meyer, 1994 ; 1996
MOOREA	Mont Mouaputa ?	1960's ?			Meyer, 1994 ; 1996
	> 10 % of the island (> 1200 ha)		10-1200	> 2000	Krantz and Schwartz, 1994 ; Meyer, unpub. data.
RAIATEA	Uturaerae valley	1955	50-400	2700-5300	Meyer, 1994 ; 1996
	2% of the island (240 ha)				*id.*
TAHAA	Pueheru valley (2 ha)	early 1980's	150	2800	Meyer and Malet, 1997
HUAHINE	Fare village (few seedlings)	mid 1990's	0	-	Meyer and Malet, 1997
MEHETIA	(few seedlings)	mid 1990's	-	-	M. Wong, pers. comm., 1997
Marquesas Islands					
NUKU HIVA	pass between Terre Deserte and Tovii plateau (7 seedlings)	1996	1100	> 3000	J.-Y. Meyer, unpub. data
	Road from Taiohae to Tovii (1 sapling)		550	-	A. Bonno, pers. comm., 1997
	Hatiheu pass (few seedlings)				W. Tetuanui, pers. comm., 1997
FATU IVA	between Omoa and Hanavave (1 tree)	early 1990's	-	-	B. Tehevini, pers. comm., 1997
HAWAIIAN ISLANDS					
O'AHU	Wahiawa Botanical Garden	1961	290	1500	Medeiros *et al.*, 1997
	Lyon Arboretum ca. 80 ha	1964	120-400	> 2000	*id.*
MAUI	Helani Gardens	early 1970's	20-490	> 2000	Medeiros *et al.*, 1997
	ca. 280 ha				Hobdy, 1997
KAUA'I		early 1980's	40-150	-	Medeiros *et al.*, 1997
HAWAI'I	Onomea	1959			K.Onuma, pers. comm., 1997
	100 000 ha		10-760	> 2000	K.Tavares, pers. comm., 1997

Fig. 2. Distribution of *M.c.* in the island of Tahiti (hatched area) in relation with the mean annual rainfall (solid line) in mm/yr



The Marquesas Islands--The recent discovery of a small population of *M.c.* in Nuku Hiva (Marquesas, Northern group) in June 1997 during a botanical expedition with botanists Steve Perlman and Ken Wood (National Tropical Botanical Garden, Kaua'i) was alarming. A total of 7 seedlings (between 20-70 cm tall) were found near the pass between Terre Déserte and Tovii plateau at 1050 m elevation. They were immediately uprooted. The plants were growing on an embankment just below the road, near the edge of pristine cloudforest. As no mature tree was found, it is likely that the seedlings originated from soil infected by *M.c.* seeds. The approximative age of the plants (according to their size) coincide with roadworks made in 1996 by bulldozers from Tahiti (Meyer, unpub. data). According to the Service du Développement Rural based in Taiohae (Nuku-Hiva), other small seedlings have been found and destroyed since the beginning of 1997 on the road from Taiohae to Tovii (A. Bonno, pers. comm., 1997) and below the pass of Hatiheu (W. Tetuanui, pers. comm., 1997).

A single plant, 4.5 m tall with a basal diameter of 15 cm., was discovered in September 1997 on the island of Fatu Iva (Marquesas, Southern group) by a young pig hunter. According to the Service du Développement Rural, the plant was located near the road between Omoa and Hanavave and was not flowering at the time of discovery (B. Tehevini, pers. comm., 1997). No seedlings have been found around the tree and a survey is currently being done by S.D.R.(J.-P. Malet, pers. comm. 1997).

SPREAD IN THE ISLAND OF TAHITI

I have reconstructed the invasion of Tahiti by *M.c.* since its first introduction through a compilation of the sightings of this species (published in scientific papers, technical reports, local magazines and other documents), and the testimony of local people who witnessed the progression of the plant in Tahiti since the 1970's (**Fig. 3**).

1937 - 1970

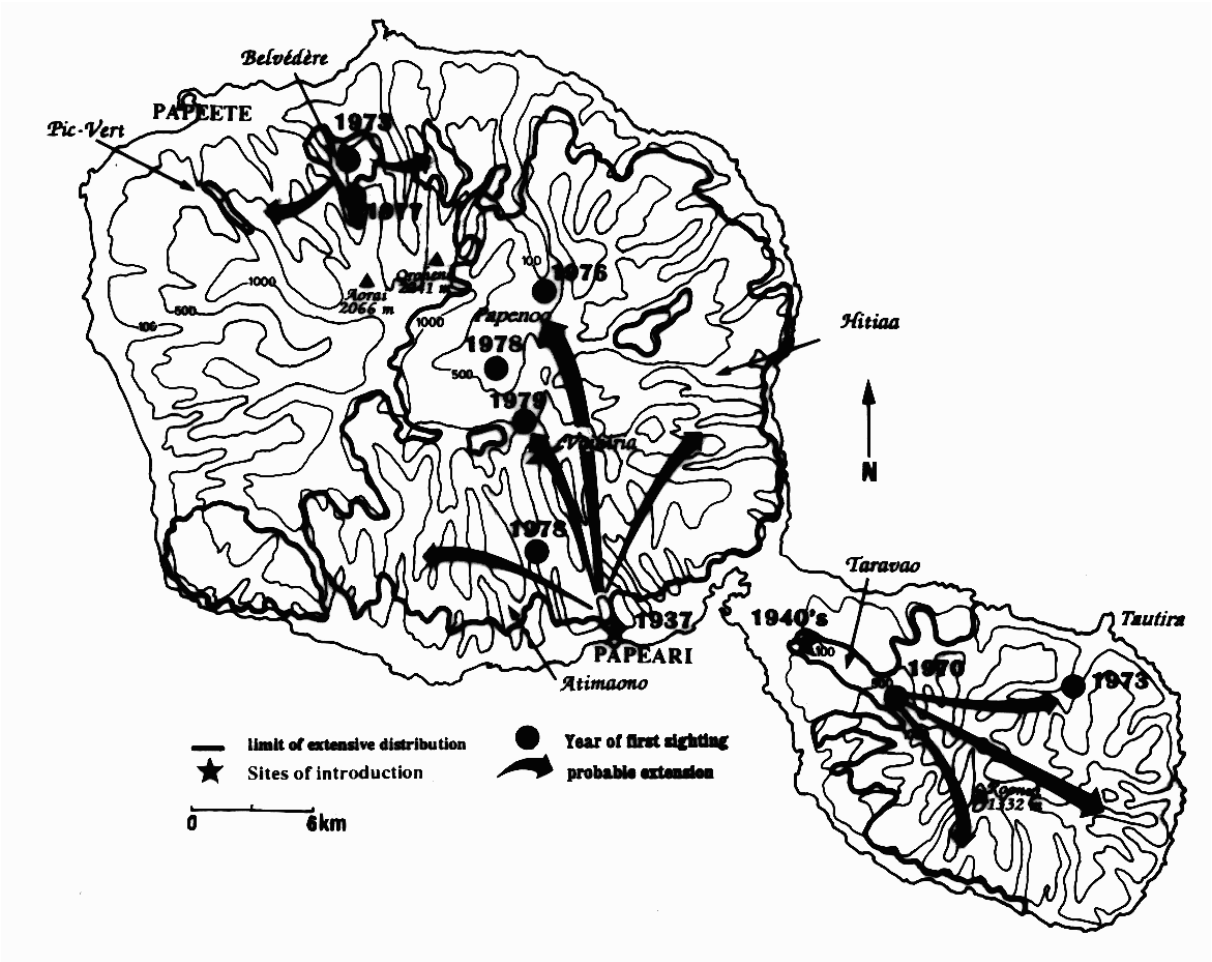
~ the species was first introduced in April 1937 in the Motu Ovini private garden owned by Harrison W. Smith and located in the district of Papeari (S-W coast of Tahiti); the plant was "potted and set out in October 1937" (Harrison W. Smith, personal unpublished notes);
~ the species was planted a few years later on the ground of the Agricultural Station on the plateau de Taravao by Jean-Marie Boubée (Raynal, 1979), an agricultural engineer who arrived in Tahiti in 1934, and a collaborator and close friend of Smith. According to Michel Guérin of the Délégation à l'Environment (pers. comm., 1997), Boubée acquired a piece of land on the Taravao plateau where he introduced many of the exotic plants cultivated by Smith. After the death of Smith in 1947, Boubée inherited the botanical garden (Barrau and O'Reilly, 1972).
~ the plant was noticed in the botanical garden of Papeari by L. G. M. Baas Becking under the name *Miconia flammea* (Becking, 1950), a taxonomic confusion that could be explained by the red-colored undersides of the leaves of this other *Miconia* species;
~ René Papy (1951-54) cited *Miconia magnifica* in the appendix, entitled "List of the alien species in the Motu Ovini private park of Papeari", of his work on the vegetation of the Society Islands;
~ the name *Miconia magnifica* is surprisingly included in 1963 in the list of the cultivated plant of French Polynesia that are attacked by parasites, expecially by *Icerya seychellarum* Westw. (Cohic, 1963). However it is not found in Jean-Noël Maclet's "List of the plants of economical interests and the main adventices plants existing in French Polynesia" (Maclet, 1958) whereas *Acacia farnesiana, Mimosa invisa, Psidium cattleyanum* and *Rubus rosifolius* are cited as noxious plants. Maclet was the director of the Harrison Smith Botanical Garden between 1962 and 1967 (M. Guérin, pers. comm., 1997);
~ the species was not noticed in a study of the organization of the district of Papeari made between 1967-68 by F. Ravault, a geographer, whereas *Cecropia peltata* is noticed to form

pure stands, and the author observed "the invasion of some coconut groves by *Psidium guajava, Lantana camara, Mimosa pudica*" (Ravault, 1980).
~ Robert Millaud, a former chief of the Service de l'Économie Rurale, showed Michel Guérin, a horticultural engineer who arrived in Tahiti for his national service, the species growing on the Taravao plateau in 1968. Guérin immediately recognized it as *Miconia magnifica*, because the plant was cultivated as a tropical ornamental in the greenhouse of the "École National Supérieure d'Horticulture" of Versailles (France) where he earned his horticultural degree.
~ in August 1969, the pharmacist and botanist Paul Pétard, visiting the *Cinchona succirubra* and *C. ledgeriana* plantations on the Taravao plateau at about 400 m elevation observed that these species were growing well "despite the colonization of purau (*Hibiscus tiliaceus*), *Aleurites*, acacias (*Leucaena leucocephala*) and miconias" (Pétard, 1986).

1970 - 1982
~ the first published record of its invasiveness was observations of dense stands on the plateau de Taravao dated in the early 1970's. Henry Whittier, in his book on the mosses of the Society Islands published in 1976 (this manuscript was accepted for publication in 1972), noticed that "there is a forest of *Metrosideros, Aleurites, Cyathea* and *Miconia* at about 800 m elevation on Taravao" (Whittier, 1976). Although Whittier cited *Lantana camara* and *Eugenia sp.* as common introduced species, nothing is said about the invasiveness of *M.c.*;
~ during one of his botanical trip to Tahiti in 1971, the botanist Raymond Fosberg of the Smithsonian Institution of Washington observed *M.c.* rapidly naturalizing on the Taravao plateau (pers. comm., 1991 *in* Loope, 1992);
~ the plant is considered to be "the number one enemy of the Tahitian vegetation" according to the botanist J. Raynal of the Natural History Museum of Paris, who noticed in September 1973 dense covers "on the top of the Taravao plateau [...], in the vicinity of the botanical garden in Papeari", "the species is said to exist around the Belvédère", and that they were "many young plants in the Vaitepiha valley at Tautira" (Raynal, unpubl. report). *M.c.* was not noticed in this valley in 1963-64 by local people working on archeological excavations for the Musée de Tahiti et des îles (V. Mu-Liepman, pers. comm., 1996);
~ Michel Guérin, who was the director of the Harrison Smith Botanical Garden between 1974 and 1988, cut down in 1974 the big *M.c.* tree (8-10 m tall) that grew in the garden and that flowers and fruits profusively, after being awarded by F.R. Fosberg and J. Raynal of the potential danger of this species (M. Guérin, pers. comm., 1997);
~ the botanists F.R. Fosberg and M.-H. Sachet observed the plant growing in wet valleys: "by 1974 it has spread to an alarming extent. Today it has supplanted all other vegetation on certain slopes on the south side of the island [...] it appears to be the major threat to the already endangered flora of Tahiti" (Fosberg and Sachet, 1981);
~ a dense stand of *M.c.* is illustrated on the cover page of the journal "Te Natura O Polynesia" (a quarterly bulletin edited by the Tahitian association for nature protection "Ia Ora Te Natura") dated of the first quarter of the year 1975, with the legend "proliferation of Miconia on the plateau of Taravao" (photo taken by J. Drollet, pers. comm., 1997);
~ the species was observed in the valley of Papenoo in 1976 during an ethnobotanical study. It presents a "particularly invasive behavior, especially in the peninsula of Taravao [...] but only a few individuals were found in the prospected area but it is said to be common higher in the valley" (Martin, 1976);
~ Steve Montgomery, Wayne Gagné and Betsy Gagné were "saddened to see the firm advances that *M.c.* has made into the native forest of the Taiarapu Peninsula above Vaiufaufa, and also to see it established below Mr. Aorai" during their trip to the Society Islands in June-July 1977 (Montgomery *et al*., 1980);
~ in November 1978, *M.c.* was observed by Gérard Mondon, a botanist of the Service de l'Économie Rurale "on complete slopes above cultivated areas" in the Teamatea Valley near Vaite river (Papeari district) and in the Vaihiria valley (G. Mondon, unpub. data). He noticed it again in October 1978 in Papenoo valley where the species "is common" up to the pass of Anuhe where "it forms dense stands";

~ in 1979 *M.c.* is located in all of the southern part of the island of Tahiti Nui, especially the Vaihiria district where it is "predominant from the coastal zone up to the Urufaau pass (at 884 m elevation between Vaihiria and Papenoo) and enters in the center of the island" (Le Vot, 1979). J. Raynal wrote in a later paper published in 1979 that "there are monospecific stands from Taravao to Vaitepiha, the main valley of Tahiti Iti" (Raynal, 1979);
~ finally, *M.c.* was found abundant around lake Vaihiria in May 1982: "the extension of *Miconia* is particularly striking on the edges of the lake where it has invaded the forests of *Cyathea-Pandanus*" (Florence, 1982).

Fig. 3. Historical spread of *M.c.* in Tahiti according to published records



The Role Of The 1982 - 1983 Hurricanes--P. Birnbaum made the statement that the hurricanes that hit Tahiti severely between December 1982 and April 1983 have caused the sudden and explosive spread of *M.c.* in the island. According to this author, the hurricanes represent "an exceptional abiotic factor" that "can explain the demographic explosion of *Miconia*" (Birnbaum, 1991); "the speed of invasion then became astonishing" (Birnbaum, 1993); "the 1983 cyclones multiplied the ecological niches favourable for this species and constitute the detonator of the demographic explosion" (Birnbaum,1994). His statement is based on (1) pre-cyclone aerial photos taken in 1978 and showing that the cover of *M.c.* in forest canopy is only 1% to 2% (100-200 ha) on the Taravao plateau; (2) an aerial photomap made in 1989 showing that *M.c.* was present on over 75% of the island and dominated a large part of the canopy (Birnbaum,1991).

However, according to the botanist J. Florence (ORSTOM/Museum of Natural History of Paris), the Taravao plateau was the only place in Tahiti where it was possible to have a good correlation between the aerial photographs of 1978 and a vegetation cover (observed on the field), mainly because it has a relatively flat terrain, and that *M.c.* may have been "elsewhere in the canopy" on Taravao plateau and "in other localities of Tahiti Iti where it was still present" (J. Florence, pers. comm. 1994). Birbaum's statement has been unfortunately found its way into several scientifical papers: "the hurricanes [...] detonated a demographic explosion of *M.c.* " (Loope, 1992); "the massive invasion of [...] forests in the Society Islands by *M.c.* following hurricanes Reva and Veena in 1983" (Medeiros *et al.*, 1995); "in the wake of two successive devastating hurricanes in 1983, a fast-growing South American melastome *M.c.*, rapidly invaded montane cloud forest habitat" (Merlin and Juvik, 1995). Although no direct evidence exists, *M.c.* is cited as a typical example of the interaction of periodic natural disturbance and forest recovery in the presence of an alien species and support of the disturbance hypothesis as an explanation of biological invasions.

What was the role of the hurricanes of 1982-83 in the extension of *M.c.*? The 6 hurricanes that hit the Society Islands between December 1982 and April 1983, with strong winds reaching 180-200 km/hr and a rainfall reaching 4 m per day (Doumenge, 1984) certainly had an enormous impact on the native vegetation. It is likely that they suppressed the canopy by breaking the top of the trees and by defoliating the emergent trees. The increased light in the understory enabled faster growth of *M.c.* seedlings already present in the shade of the native forest (as shown by the study and control of *M.c.* in the island of Raiatea (Meyer and Malet, 1997) but these were preceded by an earlier and massive establishment. An earlier and more prolific reproduction rate may have occured in this wind-disturbed canopy. Indeed, it seems that *M.c.* flowers only where the branches reach the canopy or when it attains the full light (Birnbaum 1991; Meyer, in press). Colonization of *M.c.* in open spaces such as treefall gaps or landslides created by hurricanes is less probable because the species can not establish in open sunlight and does not colonize large gaps (Meyer, 1994).

In my opinion, the hurricanes acted more as a "revealer" of the invasion of *M.c.* in 1983 than as a "detonator". According to J. Florence (pers. comm., 1994), the hurricanes "put in light, in the strict sense of the term, the invisible presence of *M.c.* " in Tahiti. *M.c.* was undoubtedly present in the understory of the secondary and native forests in the main part of the island of Tahiti before the 1982-83 hurricanes (see above, and pers. comm. of L. Stein, former chief of the Forestry Section of the Service de l'Économie Rurale). The spread of *M.c.* was not explosive, but slow and continuous, or in other words an insidious invasion ("a slow undermining establishment in the lower strata of vegetation" according to J. Florence, pers. comm., 1994).

The Lag Phase Period--Some alien species remain uncommon or very localized for long periods of time before they exhibit a rapid expansion. A genetic change (a more adapted

genetic combination), local environment changing (e.g. fire, wind, flood) or the arrival of another alien species which can act as a pollinator or a dispersal agent can explain the time-lag or lag phase (Ewel, 1986). The duration of this lag phase can reach up to 75-100 years (e.g., *Mimosa pigra* in Australia, *Schinus terebinthifolius* in Florida, *Pittosporum undulatum* in Jamaica). Longer durations of the lag time are usually explained as a consequences of major disturbance events which create conditions favoring regeneration (Bingelli, 1995).

There seems to have been a relatively short lag phase for *M.c.* of about 25-35 years between its date of first introduction and the observations of dense stands both in the Society Islands and in the Hawaiian Islands (**Table 5**). This delay might be explained by the autoecology (reproductive biology and regeneration requirements) of *M.c.* rather than by any exceptional disturbance. Studies in the island of Raiatea have demonstrated that the optimal vegetative growth of a seedling is 1.5 meter per year and that the first age of reproduction in reached after 4 to 5 years from seeds in the best ecological conditions (Meyer and Malet, 1997).

Table 5. Delay in the spread of *M.c.* in French Polynesia and in the Hawaiian Islands

ISLAND	Approximate date of introduction	First observation of dense stands	"lag phase" (yr)
FRENCH POLYNESIA			
TAHITI	1937	early 1970's	33
MOOREA	1960's	1990's	30
RAIATEA	1955	1988	33
TAHAA	early 1980's	NO (1-10 mature trees)	-
NUKU HIVA	1995-96	NO (NO mature tree)	-
FATU IVA	1990's ?	NO (NO mature tree)	-
HAWAIIAN ISLANDS			
O'AHU	1961	NO (5-10 mature trees)	-
KAUA'I	early 1980's	NO (3 mature trees)	-
MAUI	early 1970's	1993	23
HAWAI'I	1959	1985	26

If one assumes that 5-10 years is an average time to form a reproductive tree from seed, 10-20 years will be necessary to build the second generation of approximatively 10-100 reproductive trees. After a period of time between 15-30 years, the third generation will be formed by a dense cover of about 100-1000 trees (as observed on the plateau of Taravao in the early 1970's, about 30 years after its introduction). The generation times needed to form a monospecific stand from a single individual of *M.c.* may explain the lag phase we observed in the Polynesian archipelagoes. The lag between the time *M.c.* was introduced and its invasiveness could also be explained by a unnoticed expansion until the hurricane events after which the plants were quite obvious.

DISCUSSION

The Reasons Of Success--The spectacular success of *M.c.* in the Polynesian archipelagoes (Society and Hawaiian Islands) and its failure in other sites of introduction may be explained by a combination of the following reasons:

(1) The plant was introduced without its natural enemies.
In its native range of tropical America, there are numerous insects and pathogens that are present that keep *M.c.* in check and limit the spread of its natural populations. In 1993, the exploratory entomologist R. Burkhart (formerly of the Hawaii Department of Agriculture) visited the native range of *M.c.* in Costa Rica and Brazil. He noticed that the species had heavily damaged leaves. He collected several fungi including a leaf-spot fungus *Coccostroma myconae*, and a number of insects: weevils (Curculionidae); leaf beetles (Chrysomelidae); and, Lepidoptera (Limacodidae, Riodinidae and Lycaenidae) (Burkhart, 1993-94). Butterflies with colonial processional larvae *Euselasia spp.* (Lepidoptera: Riodinidae) that are voracious foliage feeders appear to be the most common and damaging of the insects occuring on the leaves of *M .c.*.

Horticulturists and gardeners have noticed the considerable susceptibility of *M.c.* leaves to phytophagous insects. Moreover, it is not uncommon to find leaves of *M.c.* in the Society or Hawaiian Islands extensively destroyed by the Chinese rose-beetle (*Adoretus sinicus*), a generalist leaf-eater that is abundant near cultivated of inhabited areas. The impact of this non host-specific insect has not been evaluated.

(2) The characteristics of the invaded zone.
Alien species find themselves in an environment different from that in which they evolved. According to Mack (1996) biotic factors are not as important barriers to naturalization and invasion as physical factors are. The similarity of an alien's home range to a potential new range is considered to be a good predictor for invasiveness (Reichard, 1997).

On the island of Tahiti there is an extremely good match between the annual rainfall and the distribution of *M.c.* The low amount of annual precipitation can also explain the failure of *M.c.* in Wahiawa Botanic Garden, O`ahu, Hawai`i. Soil nature or toxicity may explain why *M.c.* which prefers acids soils has not expanded in Jamaica and New Caledonia. *M.c.* has not invaded the Tamanu Plateau, Tahiti, (600m elev., and average annual rainfall > 3000 mm) where soils are of a clay texture and are less acid to neutral (Jamet, 1985). The structure of the vegetation (a smaller stature and a more open canopy in Polynesian forest compared to Neotropical and Sri-Lankan rainforests) may play a major role in the reproductive success of *M.c.* (Meyer, 1994; Meyer, in press).

(3) The intrinsic characteristics of the plant.
Invader species have diverse sets of ecological, physiological, genetic and morphological characteristics that make them suitable for wide dispersion, colonization and competition. With the rapid germination of seeds on a wide range of substrates and under various light conditions, a fast vegetative growth (a maximum annual growth rate of 1.5 m), an early age of reproduction (first flowering season after 4-5 years), a large and persistent seed bank (up to 50,000 seeds/sq m), the ability to self-reproduce and at least three seasons of flowering and fruiting each year (Gaubert, 1992; Meyer, 1994; Meyer and Malet, 1997; Meyer, in press), *M.c.* can be considered an "ideal weed" *sensu* Baker (1965).

Unlike many other alien species, seedlings of *M.c.* can establish in moderate or dense shade and the species does not need natural or man disturbances to become established in native forests.
(4) The "facilitation phenomenon", the opportunities and the role of chance.
Man has played a paramount role in the success of *M.c.* Its attractive purple and green foliage resulted in its introduction as an ornamental in many tropical countries, including the Polynesian Islands. Harrison Smith was in close contact with the Royal Botanic Garden,

Peradeniya, (Barrau and O'Reilly, 1972) and imported *M.c.* directly from Sri Lanka. *M.c.* was then dispersed to other islands either voluntarily as an ornamental or accidentally with infected soil or on vehicles that had not been cleaned. The tiny seeds are readily transported on boots or clothes of hikers, hunters, or anyone who has been in an infested area.

Other effective dispersal agents are frugivores attracted to the fleshy berries of *M.c.* The seeds are dispersed by alien birds (*Zosterops lateralis* and *Pycnonotus cafer*) introduced respectively in 1937 and 1979 to Tahiti, and by *Z. japonicus* in the Hawaiian Islands (and maybe *Leiothrix lutea*, widely naturalized in the native forests and a disperser of *Clidemia hirta*, A.C. Medeiros, pers. comm. 1997). Other non-native mammals such as rodents (especially the Polynesian rat *Rattus exulans* (Meyer, 1994)), cattle or wild pigs are potential dispersers. The "facilitation phenomenon" between invasive plants and alien animals as dispersal agents is well documented in other cases of biological invasion in islands.

The role of natural and anthropogenic perturbations (especially hurricanes, see above) has favored the expansion of *M.c.*. Roads are known corridors for weeds and ruderal species but also facilitate the penetration on invasive species in native forests (see the case of *M.c.* in Tahaa and Nuku Hiva discussed previously).

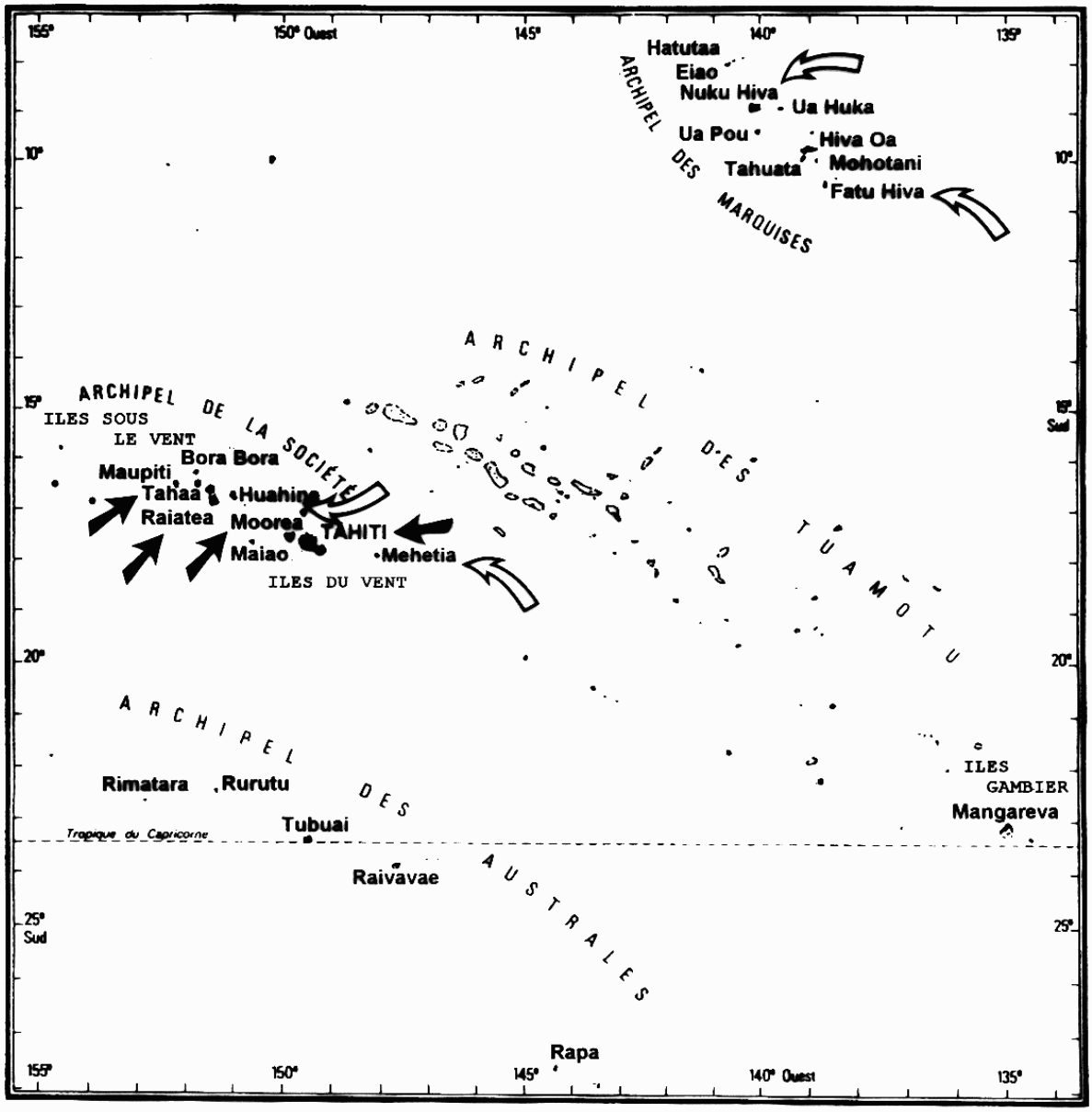
"Invasion biology is the interplay of historical chance and biological necessity" (Di Castri, 1990). *M.c.* was first introduced to Tahiti in the district of Papeari, on the wet side of the island. The Harrison Smith Botanical Garden is located close to the native wet forest into which *M.c.* could easily escape and establish itself. *M.c.* has been first used as fence posts on the Taravao plateau (as in Costa Rica, Burkhart, 1993-1994). These posts may have sprouted, as cuttings of *M.c.* are very easily propagated.

Last but not least, the lack of political decision in the 1970's to control *M.c.* in its early stage of invasion. Even though the alarm was raised by scientists and naturalists, and the potential threat of the species recognized, the lack of response enabled the expansion of the infestation, contributing to its current success. *M.c.* continued to spread until the local authorities decided, in 1988, to start a Miconia Research Program in collaboration with ORSTOM.

CONCLUSIONS

For scientists, *M.c.* represents a spectacular case of biological invasion by an introduced species in island ecosystems. In less than 50 years, this alien species succeeded to invade two-thirds of the island of Tahiti. It is now found on at least 7 high islands of French Polynesia (**Fig. 4**) and is well-established on 3 of them (Tahiti, Moorea, Raiatea). For managers of natural areas, *M.c.* is a direct threat to the native flora. The effects on the native forest are devastating, particularly on the native understory plants. Half of the endemic plants to Tahiti are considered to be directly endangered (Meyer and Florence, 1996) and 60% of the endemic flora of the Society Islands is threatened in the long term (Florence, this volume).

Fig. 4. Current distribution of *M.c.* in French Polynesia: high islands where *M.c.* was known to be present before 1997 (black arrow); high islands were *M.c.* has been recently discovered in 1997 (white arrow)



M.c. also has a great invasive potential in the Hawaiian Islands (Medeiros, Loope and Hobdy, this volume ; Conant and Nagai, this volume; Tavares, this volume), in tropical regions of Australia (Csurhes, this volume), and maybe in other new areas of introduction where it is naturalized but not yet invasive. The recent discovery of *M.c.* in Nuku Hiva and Fatu Iva in the Marquesas Islands is alarming, as well as the presence of seedlings in Huahine and Mehetia in the Society Islands. In most cases, soil movements between islands are responsible for the new introductions. These examples show that this pest can still extend its range in French Polynesia despite all the control and education efforts conducted since 1988. In all the new areas where the plant has been recently discovered, however, populations were small (usually formed by seedlings) and rapid eradication possible.

This review of the invasion by *M.c.* shows that knowledge of the bio-ecology of an introduced species both in its native country and in the new areas of introduction, and the epidemiology of its invasion, are essential elements in understanding the dynamics of invasion and the potential invasiveness of introduced species. As "the major sources of exotics will be ornamental plants" (Pickard, 1984), a special concern (early detection and control) should be given to tropical plants introduced in botanical gardens or private gardens that "escape" cultivation.

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BILAN DE LA CAMPAGNE D'ARRACHAGE DE *MICONIA CALVESCENS* AUX ILES-SOUS-LE-VENT EN 1997 ET STRATÉGIE FUTURE

RESULTS OF MICONIA CALVESCENS *REMOVAL CAMPAIGN IN THE LEEWARD ISLANDS IN 1997 AND FUTURE STRATEGY*

MAURICE WONG, SERGE AMIOT & ÉMILE BROTHERSON
Service du Développement Rural, B.P. 13 Uturoa, Raiatea, POLYNÉSIE FRANÇAISE.

Miconia calvescens est présent sur Raiatea depuis 1955 et quelques foyers isolés ont été identifiés sur Tahaa depuis 1995. Sa répartition géographique couvre principalement la partie nord de l'île de Raiatea sur 240 hectares. Les différentes campagnes d'arrachage depuis 1992 ont permis d'arracher 645000 plants dont 599 plants reproducteurs en cinq campagnes.

La campagne 1997 a vu la participation de 182 scolaires pour une journée, de 30 agents du Service du Développement Rural et de 90 militaires de l'Armée française sur une semaine. Elle a permis d'arracher 68000 plants dont une cinquantaine de plants reproducteurs sur 190 hectares. La baisse du nombre de plants trouvés indique une diminution de la population de *M.c.* présente dans la zone. Mais la présence de plants reproducteurs est un signe inquiétant qui nous oblige de prévoir une lutte sur plusieurs années encore.

Les campagnes d'arrachage sont exigeantes en logistique : nettoyage de pistes d'accès, identification des zones d'arrachage, transport des équipes de lutte, préparation du matériel, etc. Jusqu'à présent, seuls les agents du SDR sont pleinement mobilisés dans cette lutte.

Dans le futur, la stratégie de lutte consiste à éliminer tous les plants avant le stade reproducteur et d'épuiser la banque de semences. Elle doit mobiliser principalement la population des îles avec un encadrement des agents de l'administration, sans exclusive de ceux du SDR. Afin d'éliminer tous les plants reproducteurs, il sera sans doute nécessaire d'effectuer quatre campagnes successives sur toutes les zones identifiées. Puis seulement, il sera possible d'envisager des campagnes une année sur deux ou par zones délimitées pour éliminer les plants juvéniles.

Miconia calvescens *has been present on the island of Raiatea since 1955 and a few isolated infestations have been identified in Tahaa since 1995. Its geographical range mainly covers over 240 hectares of the northern part of Raiatea. The various removal campaigns since 1992 have destroyed 645,000 plants including 599 reproductive plants in 5 campaigns.*

The 1997 campaign involved the participation of 180 schoolchildren for one day, 30 Rural Development Service agents and 90 soldiers of the French Army for one week. 68,000 plants were removed, including about 50 reproductive ones, over 190 hectares. The lower number of plants detected indicates a decrease in the M.c. *population present in the area. But the presence of reproductive plants is a worrying sign that requires the preparation of a control programme for several more years.*

The removal campaigns require a great deal of logistics: clearing the access paths; identifying the eradication areas; conveying the control teams; preparing the equipment; etc. Up until now, only the agents from the SDR are involved as a full-time activity in such a task.

In the future, the control strategy will consist of eliminating all the plants before they reach the reproductive stage thereby drying up the seed bank. For such a purpose, the populations of each island must be mobilized under the supervision of the agents of the administration, including but not limited to those of the SDR. In order to eliminate all reproductive plants, it will be necessary to carry out four successive campaigns in all infested areas. Only afterwards will it be possible to envisage campaigns every other year, or over delimited areas to eliminate juvenile plants.

SESSION 2

ÉTUDE ET LUTTE CONTRE *MICONIA CALVESCE*
À HAWAI'I ET EN AUSTRALIE

CONTROL OF INFESTATIONS ORIGINATING FROM SINGLE *MICONIA CALVESCENS* PLANTS ON O'AHU AND KAUA'I, HAWAI'I

LE CONTROLE DE ZONES INFESTÉES PROVENANT DE PLANTS ISOLÉS DE MICONIA CALVESCENS *À O'AHU ET KAUA'I, HAWAI'I*

PATRICK CONANT[1], AND GUY NAGAI[2]

[1]Hawaii Departement of Agriculture, Plant Pest Control Branch, 1428 South King St, Honolulu, O'ahu, HI 96814, HAWAI'I (USA).
[2]Hawaii Departement of Agriculture, 4398 East Pualoke Street, Lihue, Kaua'i, HI 96766, HAWAI'I (USA).

Miconia calvescens has only recently been documented as an extremely invasive and ecologically disruptive introduced plant in Australia, Hawai'i, French Polynesia, and a few other oceanic islands. In Hawai'i, chemical/mechanical control methods are now being applied to eradicate it locally or contain it where infestations are large. The Hawaii Chapter of the Sierra Club has been instrumental in organizing volunteers to successfully contain the weed at infestation sites on O'ahu. During control actions by volunteers, measurements were made of total number, height, diameter at breast height and reproductive status of all plants too large to hand pull. There are six known infestations of *M.c.* on O'ahu and one on Kaua'i. There were apparently seven known original plantings of the tree on O'ahu and three on Kaua'i. The trees at Tantalus, Waimea and Wahiawa botanical gardens are not known to have produced progeny that reached reproductive size. Two trees on Kaua'i planted remotely from the main infestation were not known to have produced any progeny. All other planted trees on O'ahu (Kalihi, Nuuanu and Manoa) and Wailua on Kaua'i did produce progeny that reached reproductive age. No reproductive-size trees are now known to exist on either island as of August 1997. However, continuing follow up ground and aerial surveys of all infestations over the next decade will be critical to containment of *M.c.*. This containment demonstrates that even in the absence of adequate government financial support, if infestations are detected early, volunteers can get the job done. All known infestations on Kaua'i and O'ahu were started from single reproductive plants. Unfortunately, precise planting dates of the original plants from which infestations originated have been difficult to obtain. Nonetheless, the measurements may be useful in predicting some aspects of population growth of this weed.

Miconia calvescens *n'a été que seulement et récemment décrit comme une plante introduite extrêmement envahissante et écologiquement perturbatrice en Australie, à Hawai'i, en Polynésie française et dans quelques autres îles océaniques. A Hawai'i, les méthodes de lutte chimiques/mécaniques sont maintenant appliquées pour l'éradiquer localement ou le contenir dans les zones fortement infestées. L'action de la section hawaiienne du Sierra Club a été décisive en encadrant des volontaires pour contenir avec succès* M.c. *dans les sites infestés de O'ahu. Durant les efforts de lutte menés par les volontaires, les mesures de quelques paramètres ont été effectuées (nombre, hauteur, dbh, statut reproductif) sur toutes les plantes trop grandes pour être arrachés à la main. Il y a six zones infestées par* M.c. *connues à O'ahu et une à Kaua'i. Sept arbres ont été apparemment plantés à l'origine à O'ahu et trois à Kaua'i. Les arbres plantés de Tantalus, des jardins botaniques de Waimea et de Wahiawa ne sont pas connus pour avoir donné une descendance ayant atteint la taille reproductrice. Deux arbres plantés à Kaua'i loin de la principale zone infestée ne sont pas connus pour avoir donné de descendance. Tous les autres arbres plantés à O'ahu (Kalihi, Nuuanu et Manoa) et Wailua à Kaua'i n'ont pas donné de descendance ayant atteint l'âge reproducteur. On ne connaît aucun arbre à taille reproductrice dans ces deux îles jusqu'en août 1997. Cependant, un suivi continu sur le terrain et une surveillance aérienne de toutes les zones infestées pendant la prochaine décennie sera nécessaire pour contenir l'extension de M.c.. Ce contrôle montre que même sans un soutien financier gouvernemental adéquat, et si les zones infestées sont détectées de façon précoce, les volontaires peuvent faire le travail. Toutes les zones connues à O'ahu et Kaua'i ont démarré par un seul pied reproducteur. Malheureusement, les dates précises d'introduction des plantes originelles ont été difficiles à obtenir. Néanmoins, les paramètres mesurés peuvent être utiles pour la prédiction de certains aspects de la croissance des populations de* M.c.

Miconia calvescens is a small, early successional tree native to the Neotropics and adapted to colonizing light gaps in wet thickets and dense mixed forest (R. Burkhart, pers. comm.). Its adaptations to its habitat have apparently made it a very successful invader in semi-tropical and tropical oceanic islands. The history and spread of this weed in Hawai'i and French Polynesia have been documented (Medeiros *et al*., 1997; Meyer, 1996), but little is known of its invasiveness in Sri Lanka, Australia, New Caledonia and Grenada (Meyer, this volume). On the island of Tahiti in French Polynesia, it is now known to dominate approximately 65% of the forested area of the island (Meyer 1996). Three other islands there are infested to a lesser degree. In decreasing severity of infestation, they are Moorea, Raiatea and Tahaa (Meyer, this volume). In Hawai'i, four islands are infested and in decreasing order of severity they are: Hawai'i, Maui, O'ahu and Kaua'i (Medeiros *et al.,* 1997). Hawai'i and Maui islands now have small, full-time, paid crews to search for and control infestations (Tavares, this volume; Medeiros, Loope and Hobdy*,* this volume). On O'ahu and Kaua'i, however, containment has been achieved mostly by volunteers and the part-time effort of state government employees. All of the infestations on these two islands started from intentionally planted single trees. This paper documents the containment of *M.c.* on the islands of Kaua'i and O'ahu and summarizes the parameters measured for each population.

HISTORY OF *MICONIA CALVESCENS* INFESTATIONS ON O'AHU AND KAUA'I

Medeiros *et al*. (1997) reviewed the history and status of *M.c.* in Hawai'i by island. We will update that information here, and add detail to the historical record. The information in Medeiros *et al*. (1997) for the infestation sites on the island of Kaua'i is still current. The planting date of the original tree remains unknown. The description presented in Medeiros *et al*. (1997) of the O'ahu infestions lacks some details, which should be documented to understand the spread of the weed on that island. There are presently six known original plantings of individual *M. calvescens* plants on O'ahu (**Fig. 1**). Medeiros *et al.* (1997) described five of these sites, some in greater detail than others. Some additional information will be presented here, by site, and the sixth site is discussed.

O'AHU

Waimea Valley and Wahiawa--No new finds of *M.c.* have been made in these areas. The original specimen planted in 1976 at Waimea Botanical Garden was removed when it was only about 1m tall according to K. Wooliams (pers. comm.) so it never flowered. The original Wahiawa Botanical Garden specimen, planted in 1961, was donated by the famous naturalist Joseph Rock. Only two progeny are known to have escaped the grounds of the garden. Of the two saplings pulled up in 1995 and 1996, one was across the street from the arboretum, and the other was in Helemano housing area and was apparently large enough to have fruited (**Fig. 2**). The property owner did report pulling up seedlings near this 7.6 cm dbh tree. It is important to note that the original Wahiawa Botanical Garden specimen was reported to be kept pruned over it's lifetime (J. Sands, pers. comm.), which may have reduced fruiting.

Lyon Arboretum (upper Manoa Valley)--Since the original specimen planted in 1964 began to fruit, *M.c.* seedlings continue to be found by arboretum staff, primarily in the northwest sections of the maintained grounds. The most recent find of a fruiting tree was in January 1997 on the forested unmaintained montane lands. Surveys of Lyon Arboretum upper elevation lands have been temporarily suspended to allow seedlings to grow taller and become more visible. The arboretum staff has cut trails into the most infested gully to search for and remove seedlings.

Fig. 1. *M.c.* distribution on O'ahu (March 1998). Points shown reflect locations from hand-sketched maps and Global Positionig System coordinates.

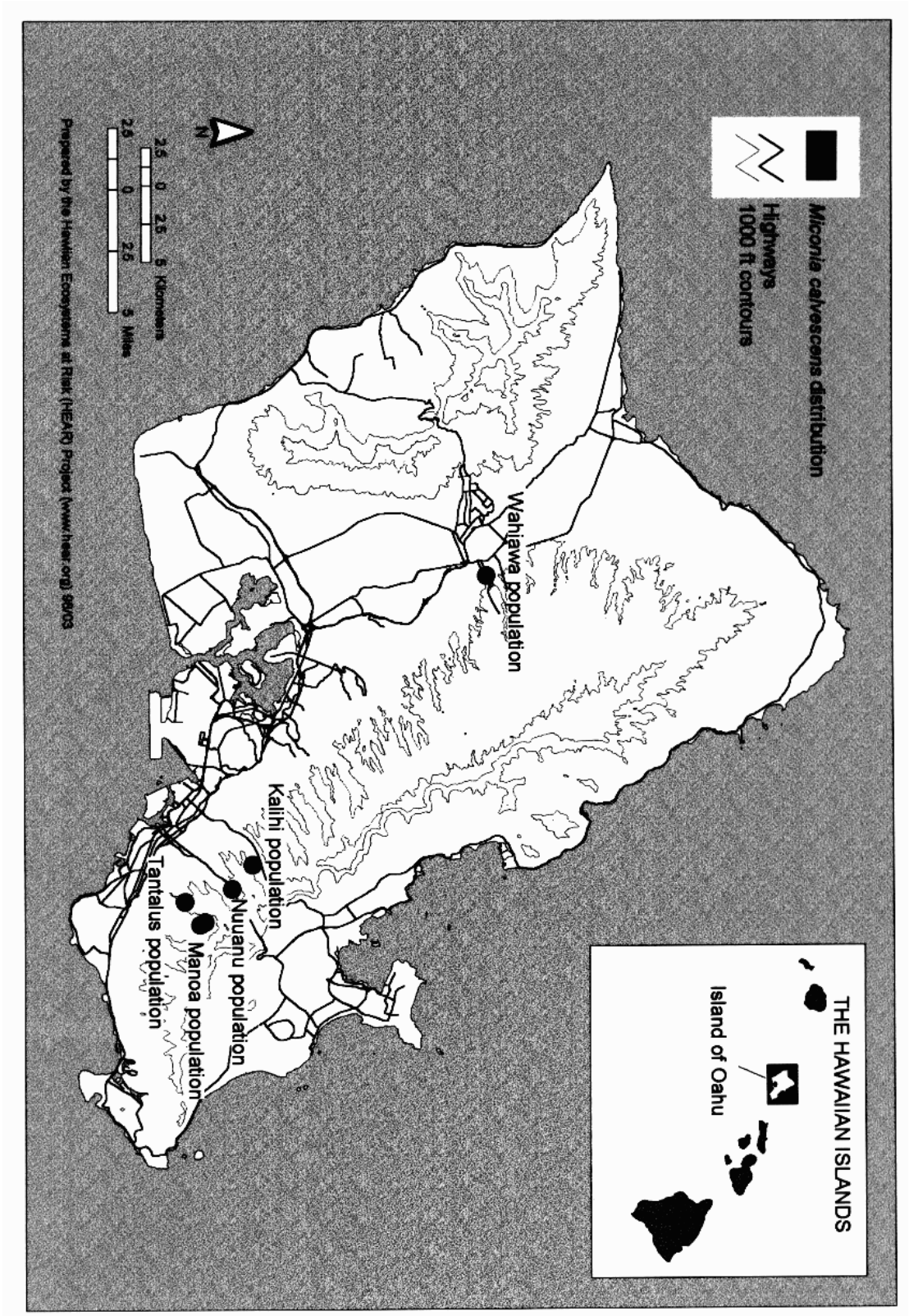
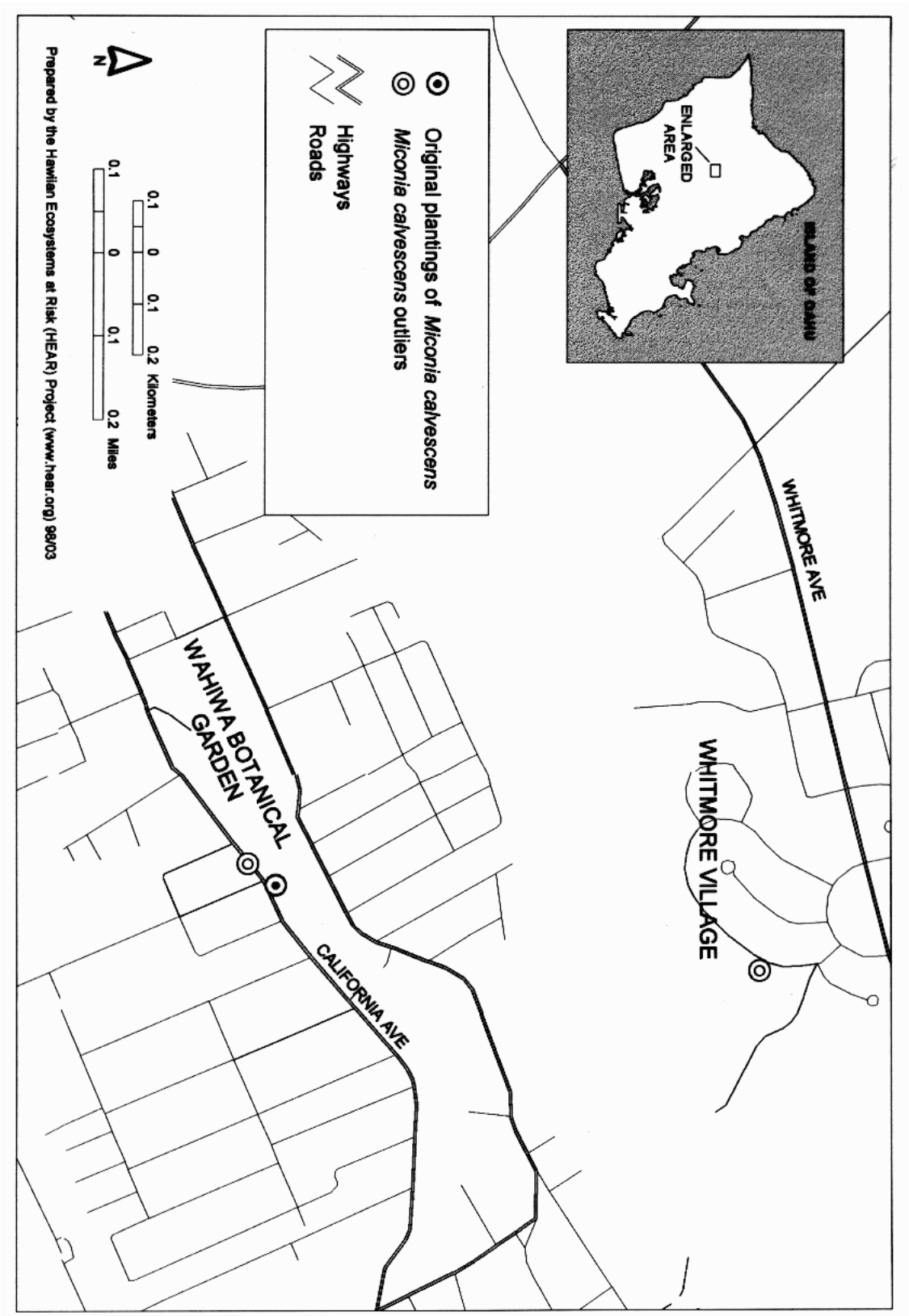


Fig. 2. *M.c.* locations in Wahiawa (March 1998). Original Wahiawa Botanical Garden plant shown with its two known progeny. Points shown reflect locations from hand-sketched maps and Global Positionig System coordinates.



Paradise Park property (upper Manoa Valley)--W. Wong (pers. comm.) of Paradise Park Community Foundation believes the original specimen was planted on the premises of that institution next to the main building was in 1978. Saplings too large to pull up (TLPU) continue to be found by the Hawaii Department of Agriculture (HDOA) and the Department of Land and Natural Resources, Division of Forestry and Wildlife, Natural Area Reserve System (DOFAW-NARS) staff on the western slope of the Paradise Park property (**Fig. 3**). However, no reproductive plants have been found since May of 1996.

Nuuanu Valley--The planting date of the original tree at the Marks Estate on Old Pali Road is uncertain (Conant, 1996), but according to E. Marks Stack (pers. comm.), it was probably planted about 1961. The large size (17 cm diameter at breast height or dbh) that the tree attained supports this estimated date. Periodic roguing sweeps of the neighborhood by HDOA staff remove a few seedlings each time, and numbers are steadily decreasing (**Fig. 3**).

Kalihi Uka, Kalihi Valley--The original tree in Kalihi was planted on government land leased to a private plant nursery. The year is unknown but according to the son of the now deceased owner, it was most likely before 1970, when the owner of the nursery died (C. Choi, pers. comm). The nursery was eventually abandoned and the tree was left to grow in an adjacent gully. It was rediscovered by a Sierra Club member in December of 1994 who had previously worked at the nursery (C. Yamane, pers. comm). By that time, it had attained a dbh of 12cm and was producing fruit. The Hawaii Chapter of the Sierra Club service trips to contain *M.c.* at that site have continued since April of 1995. Since the publication of Medeiros *et al*. (1997), the perimeter of the infestation has been expanded slightly by the discovery of a few plants two gullies to the southwest of the original plant (**Fig. 3**).

Puu Kakea, Tantalus--A single *M.c.* was reported on April 24, 1997 by a property owner at Puu Kakea, near Mt. Tantalus. The identification of a 0.5m tall seedling was confirmed by N. Matayoshi of HDOA (pers. comm.). A subsequent visit to the site revealed a large mature tree that had recently fruited and on which bare panicles were still visible. A plastic pot remnant still partially surrounded the base of the tree, indicating it was a planted specimen. Two saplings (about 1.5 and 3m tall) were also removed nearby. A total of nine seedlings, all less than 0.5m tall have since been removed in a small area about 100m from the planted tree (**Fig. 3**).

KAUA'I

Wailua and Kapaa Homesteads--No new reports of any *M.c.* have been made anywhere on Kaua'i since the publication of Medeiros *et al*. (1997) (**Fig. 4**). The original tree was planted in a commercial nursery. Birds apparently moved seed off the property into the surrounding rural area and the drainage of Wailua River. Using GPS coordinates of the outlier plants of the infestation, The Hawai'i Ecosystems at Risk Project has estimated the area of this infestation to be 220 hectares, excluding two known planted specimens north of the infestation. The original tree produced at least four progeny that reached reproductive age and a few others of similar size. The outlier planted trees are both within a four km. distance of the core infestation. Neither of those are known to have produced progeny, although one had panicles when it was found (**Fig. 5**).

Fig. 3. *M.c.* locations infestation extents in South O'ahu (March 1998). Points shown reflect locations from hand-sketched maps and Global Positionig System coordinates.

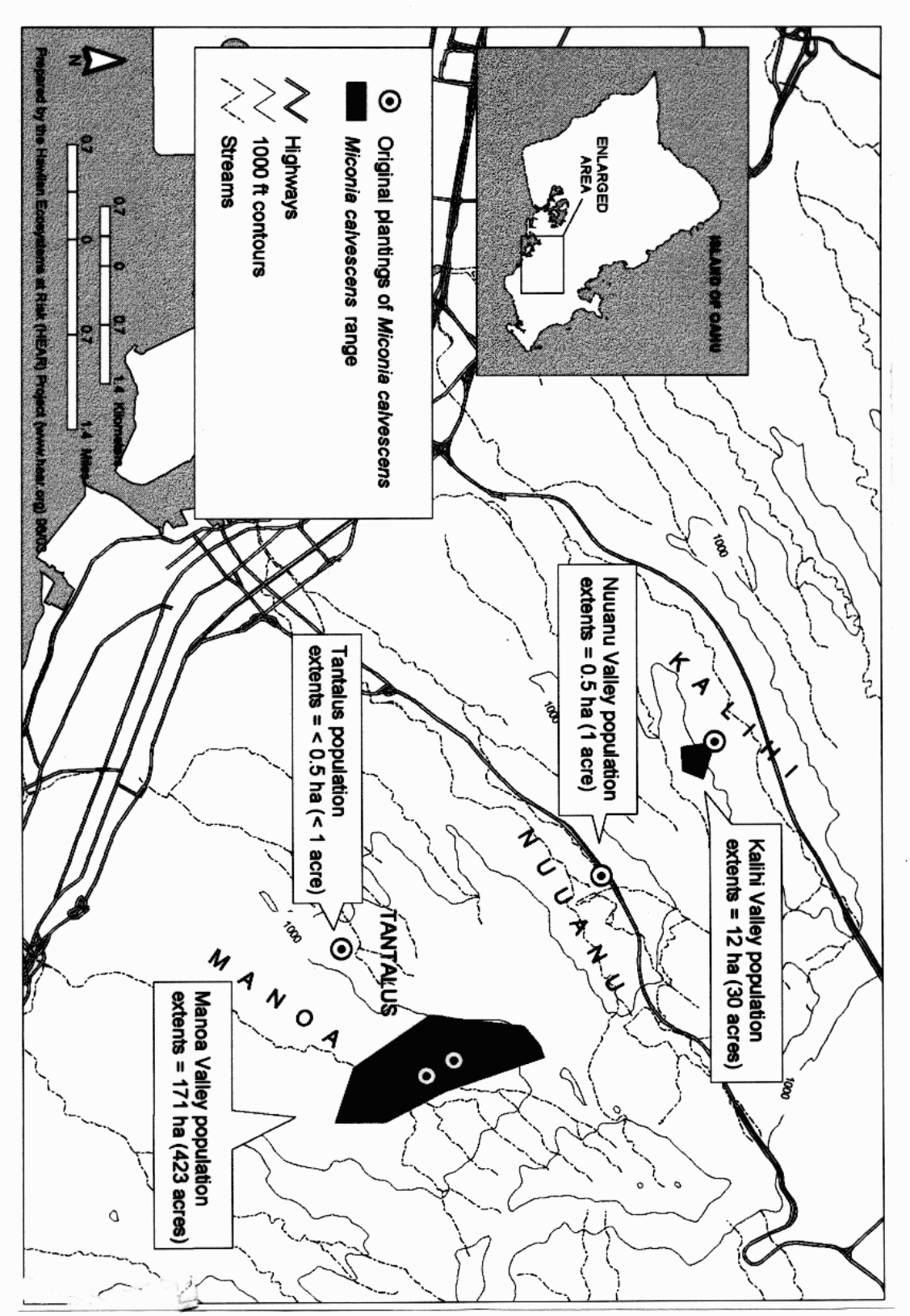


Fig. 4. *M.c.* distribution on Kaua'i (January 1998).

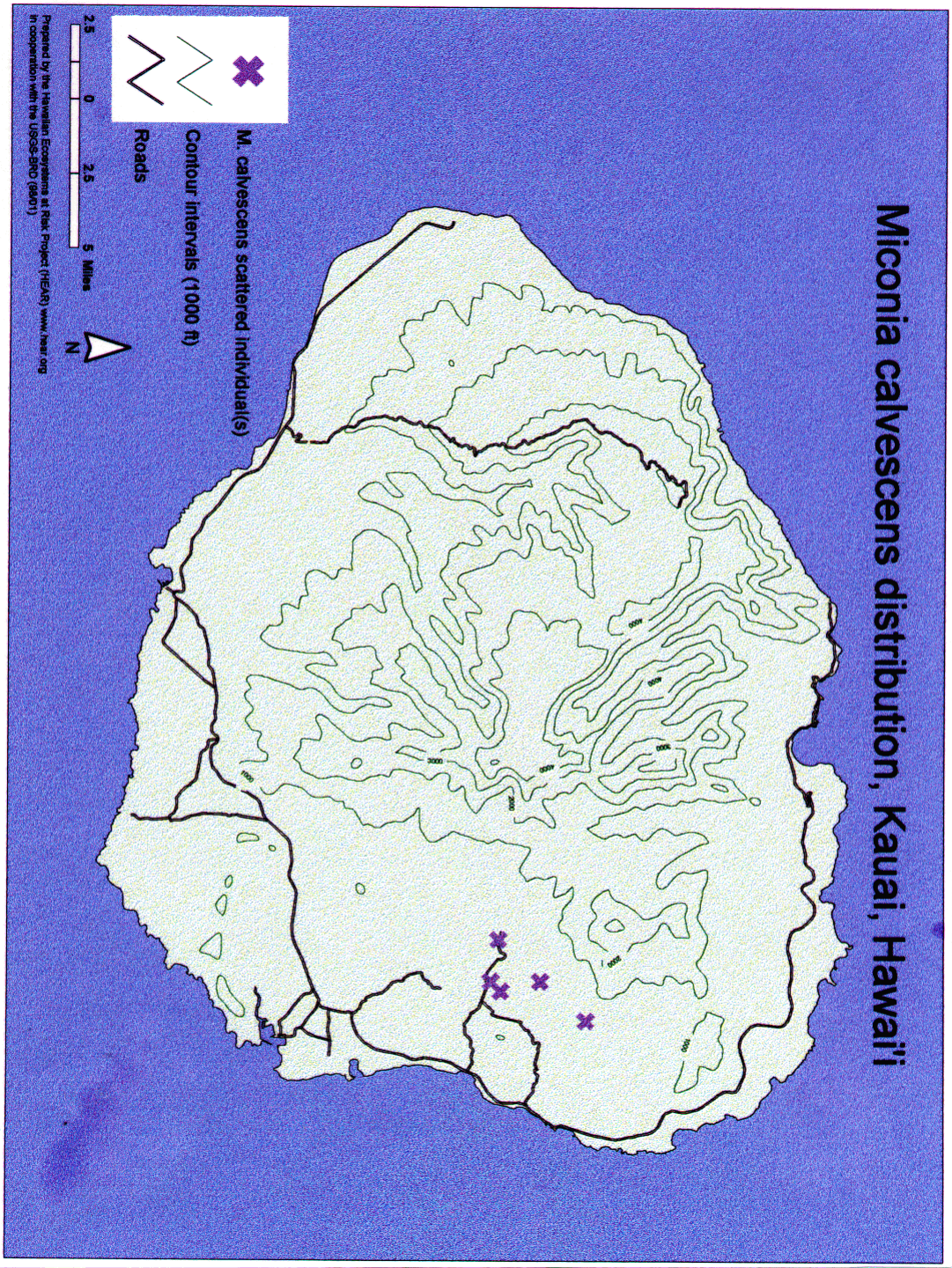
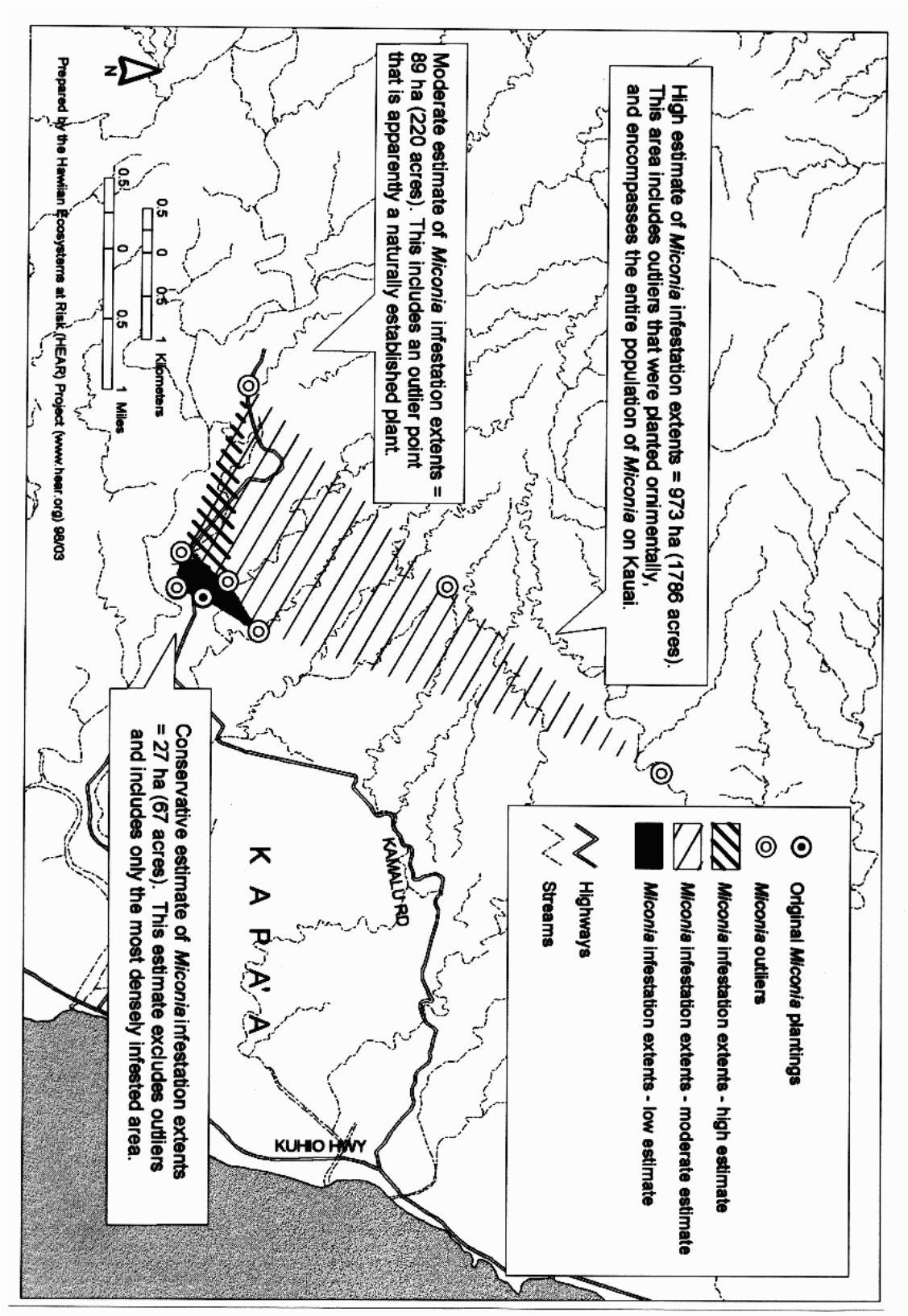


Fig. 5. *M.c.* locations infestation extents on Kaua'i (March 1998). Points shown reflect locations from hand-sketched maps and Global Positionig System coordinates.



MATERIALS AND METHODS

The containment of *M.c.* on O'ahu and Kaua'i has been accomplished by the efforts of volunteers and the staff of the Department of Agriculture, Plant Pest Control Branch (HDOA-PPC), Department of Land and Natural Resources, Division of Forestry and Wildlife, Natural Area Reserve System (DOFAW-NARS), and the Lyon Arboretum, University of Hawai'i. In the early stage of the containment operations on both islands, little data was collected on the characteristics of the infestations. As the peak of seedling removal was passed, efforts to measure a few parameters of the plants were begun. However, on the island of Kaua'i, most of the plants were destroyed before many measurements were taken. On O'ahu, since April of 1993, all *M.c.* plants too large to pull up (TLPU; greater than about ca. 2-3m tall) had measurements of dbh, estimated height, presence of flowers or fruit, number of panicles and presence of seedlings below the trees. Counts of smaller plants were initially deemed too unreliable due to their large numbers and the potential error in reporting.

All TLPU plants were treated with full strength Garlon 3A by notching the trunk. If fruit was present, the tree was cut down and the stump was treated with the same herbicide concentrate. Fruit was bagged and carried out for disposal. Mapping of the extent of each infestation has been done using county tax maps, topographical maps, and both hand-held and helicopter-mounted Global Positioning System (GPS) units. The Geographic Information System of the Hawai'i Ecosystems at Risk Project database has stored the GPS coordinates that outline the outliers of the Manoa and Kalihi infestations and also the Kaua'i infestation. The other infestations on O'ahu are much smaller and are recorded on paper maps kept in HDOA files.

RESULTS AND DISCUSSION

The infestations of *M.c.* on O'ahu and Kaua'i are unusual in that the exact location of all the original plantings of the weed are apparently known. In all cases, only a single specimen was planted, which then would have had to self-pollinate to start an infestation. Germination of seeds of *M.c.* is known to be up to 90% under optimal laboratory conditions (Meyer, 1994). Mature reproductive age trees on O'ahu have typically had very low numbers of seedlings under them. There are several possible explanations for this: soil conditions are not conducive to germination; birds or rodents are efficiently carrying seeds far off-site; a single reproductive plant does not by itself create a large seed bank in the first 15-20 years of growth; or, the low light levels on the forest floor inhibit germination. Lloyd Loope (pers. comm.) believes the most plausible explanation is that this is a result of low light conditions on the forest floor in the typically dense canopy alien forest that *M.c.* ocupies in Hawai'i. This is supported by observations on Maui where defoliation of the canopy by aerial herbicide spraying did produce copious germination of seeds on the ground (L. Loope, pers. comm.).

Figures 6 through 9 show the size classes of progeny of TLPU saplings of the original planted trees at the larger O'ahu infestation sites. Note that very few progeny of original plants had approached reproductive size (approximately 4cm dbh; J.-Y. Meyer, pers comm), in Nuuanu or Kalihi (**Fig. 6** and **Fig. 7**). Figures 8 and 9, however, show that several saplings greater than 4cm dbh were removed in the contiguous Paradise Park and Lyon Arboretum infestations in Manoa. It should be noted that both the original Nuuanu and Wahiawa trees were apparently kept somewhat pruned, which may have reduced fruit set and numbers of progeny (**Fig. 8** and **Fig. 9**). Relatively few progeny of original trees were found with flowers or fruit. In both Kalihi and Nuuanu, only one progeny plant had fruit or flowers. Paradise Park Property had two such plants while Lyon Arboretum had five. However, it is unclear whether these counts may be only a reflection of the seasonal phenology of the plant (plants were not in reproduction at the time they were found) or, may indicate many plants were too young to begin reproduction.

Fig. 6. Dbh classes of TLPU saplings at Nuuanu.

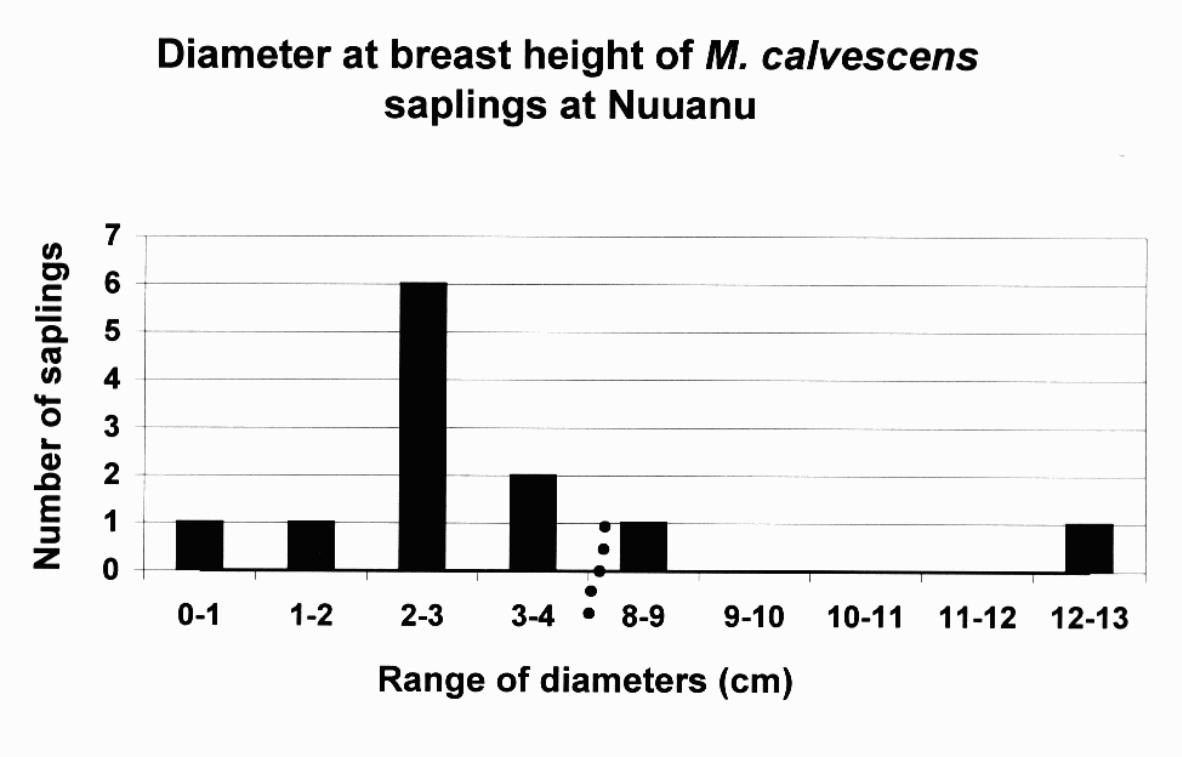


Fig. 7. Dbh classes of TLPU saplings at Kalihi.

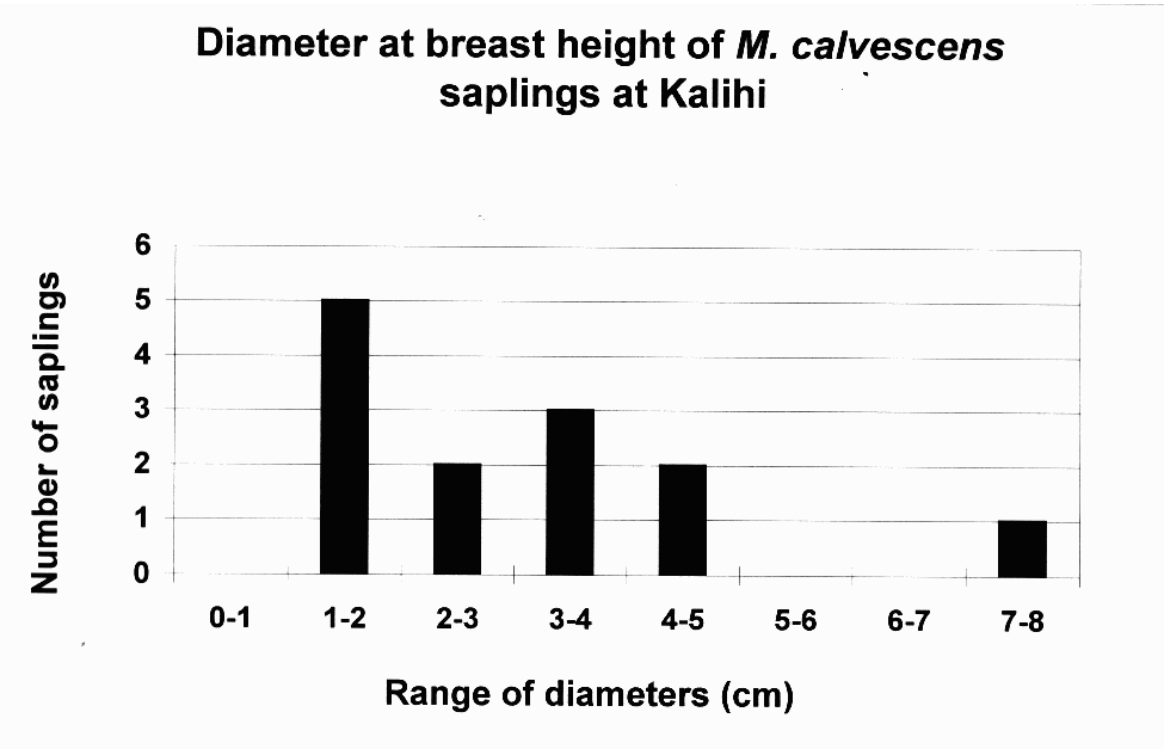


Fig. 8. Dbh classes of TLPU saplings at Paradise Park, Manoa

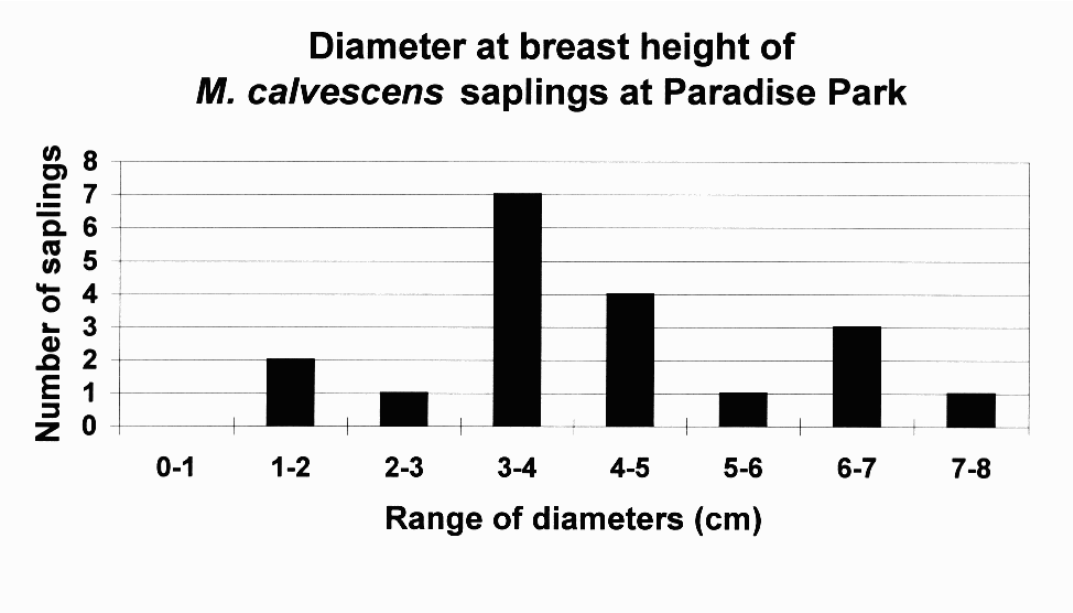
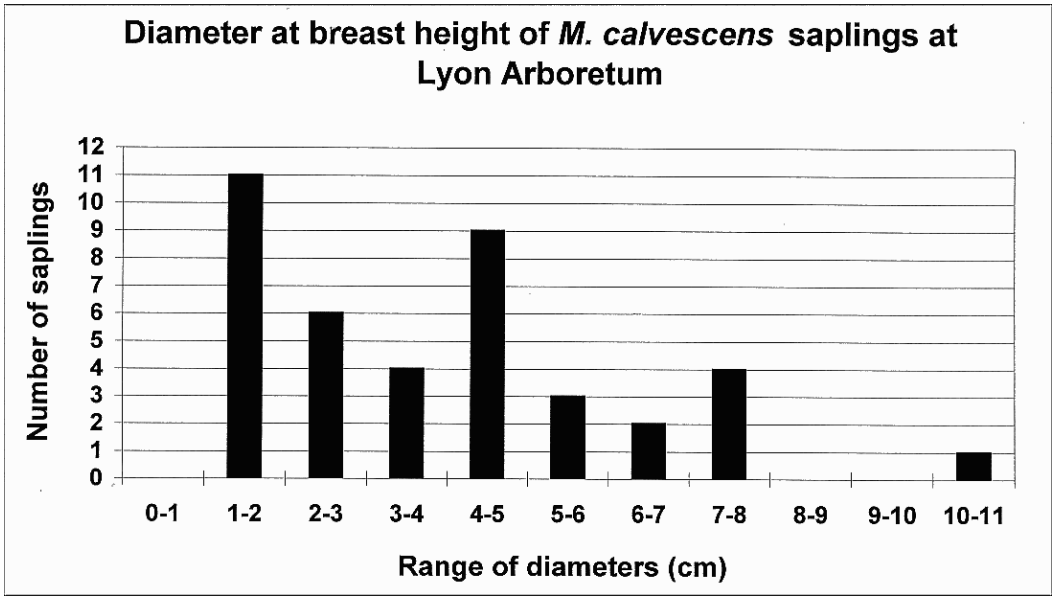


Fig. 9. Dbh classes of TLPU saplings at Lyon Arboretum, Manoa

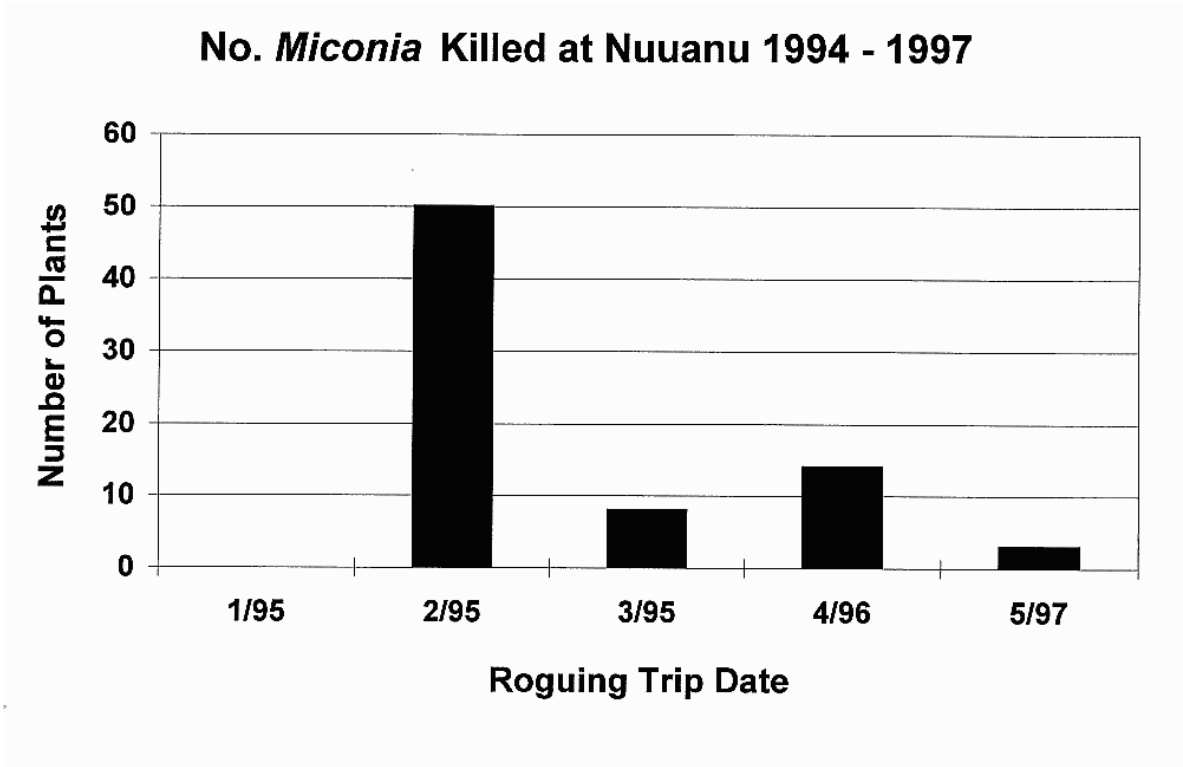


Meyer and Malet (1997) found that seeds survived in soil up to four years (when experiments were terminated) in Tahiti. Our observations at infestation sites on O'ahu indicate that seed banks at some sites are becoming exhausted through the periodic roguing of new seedlings. Unfortunately, counts of seedlings were not always made initially at infestation sites because of the potential for inaccurate counts of large numbers of seedlings. However, complete counts of plants removed were made from the beginning of the control effort at the Nuuanu infestation. Figure 10 shows that the counts of rogued seedling at Nuuanu has dropped to a very low level in slightly over two years (**Fig. 10**).

It is unfortunate that the precise planting date of all the original trees is not known. This information would make the determination of the rate of dispersal and age composition of the progeny more precise. Nonetheless, the data that have been collected indicates that all the infestations on O'ahu and Kaua'i have been successfully contained. Surveys will need to continue at all sites indefinitely to remove plants before they reach reproductive age. Helicopter surveys are critical to finding large emergent trees and ground surveys are needed to search under the canopy.

On Kaua'i, an early, concerted effort to find and remove all *M.c.* at the known infestation site led to apparent containment in the relatively short period of six months. No precise numbers of progeny large enough to reproduce were kept. However, only four plants were ever found with flowers and all flowers seen were immature. Three helicopter searches have been conducted since the last plant was found but no new finds have been made. The total number of plants found so far is 62, and 26 of these were found on the property of the nursery that had the original plant.

Fig. 10. Total number of *M.c.* killed at Nuuanu: 1994 throuh 1997



USE OF VOLUNTEER WORKERS

Volunteers have been a critical component of the containment of *M.c.* on Kaua'i and O'ahu. On Kaua'i, volunteers distributed "*Miconia* fliers" house-to-house throughout the entire area surrounding the infestation site. This effort led to reports of outlying plants and was critical to defining the area of the infestation. On O'ahu, volunteers from the Girl Scouts of America, 4-H Club, Hawaiian Botanical Society, and Kamehameha Schools distributed fliers door to door. The Hawaii Chapter of the Sierra Club has done the bulk of the roguing work at the two largest infestation sites, Manoa and Kalihi Uka. Sierra Club members and accompanying volunteers from the community have invested over 835 man hours searching for and removing *M.c.* in these two valleys. Table 1 shows the costs incurred so far in the O'ahu containment program, excluding the all volunteer canvassing effort. It is obvious that using a primarily volunteer effort has kept the cost of containment low (**Table 1**).The Sierra Club Hawaii Chapter newsletter, *Malama I Ka Honua*, advertises the *Miconia* removal service trips in the hike schedule and a small notice often also appears in the weekend activity sections of a local newspaper. One-page announcements are also sent by fax to several conservation-related organizations prior to each event. The awareness of the general public has been kept high through periodic media reports on the threat of *M.c*. Without this awareness, volunteer participation would probably be much less.

The two large *M.c.* infestations on O'ahu, Manoa and Kalihi Uka, are both primarily on steep rugged terrain. The Manoa site in particular has little level ground except where the Arboretum staff manage the vegetation. It became increasingly clear with each monthly removal trip that all volunteers were eager to help, but not all of them were comfortable climbing steep slippery slopes. It became necessary to advertise the missions as being "strenuous, off-the-trail and on steep slippery terrain". Also, to allow everyone to participate, the volunteer group on each trip was split into two teams, one for more level terrain and one for steeper terrain. This worked very well for the Kalihi Uka site but not in Manoa, where the remaining unsearched areas were all steep. Allowing everyone who volunteers to actively participate in control work helps keep up enthusiasm among the pool of community volunteers.

Table 1. Costs incurred on O'ahu for containment of *M.c.*

ITEM	DOLLAR VALUE	MAN HOURS
1 liter garlon 3A (HDOA[1])	25.00	-----
rubber gloves, goggles calipers (HDOA[1])	75.00	-----
5.5 hrs. helicopter time (DOFAW[2] or HECO[3])	3,500.00	13 (HDOA[1], DOFAW[2], LA-UH[3])
C/M work in Manoa, Kalihi, Nuuanu, Wahiawa	3,525.00	235 (HDOA[1] & DOFAW-NARS[2] staff)
confirmation of *Miconia* reports		80 (HDOA[1] staff)
Sierra Club Service Trips: Manoa, Kalihi	no cost	>835 (Sierra Club volunteers and LA[4] staff)
TOTALS	$7,125	1,163 man hrs.

[1]Hawaii Department of Agriculture; [2]Hawaii Division of Forestry and Wildlife, Natural Areas System ; [3]Hawaiian Electric Co.; [4]Lyon Arboretum, University of Hawai'i

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INTERAGENCY EFFORTS TO COMBAT *MICONIA CALVESCENS* ON THE ISLAND OF MAUI, HAWAI'I

EFFORTS INTER-SERVICES POUR COMBATTRE MICONIA CALVESCENS *SUR L'ILE DE MAUI, HAWAI'I*

ARTHUR C. MEDEIROS[1], LLOYD L. LOOPE[1], AND ROBERT W. HOBDY[2]

[1]U.S. Geological Survey, Biological Resources Division, Haleakala National Park, P.O. Box 369, Makawao, Maui, HAWAI'I (USA).
[2]Hawaii Department of Land and Natural Resources, 54 South High Street, Wailuku, Maui, HAWAI'I (USA).

Maui is the Hawaiian island where efforts to combat *Miconia calvescens* were first mobilized. An alarm of *M.c.*'s presence on Maui was first raised in 1991, about 20 years after its original introduction to the island. This alarm was taken seriously (based solely on *M.c.*'s track record in Tahiti), and removal of the seven known populations in lowland, windward East Maui was undertaken, but the ability of the species for dispersal was underestimated. By late 1993, when a more comprehensive assessment of the problem was in hand, several thousand fruiting trees were already present in a relatively inaccessible area (on a 500-year-old lava flow, with rugged substrate) upslope of the original introduction. In response to the severity of the threat, a multi-agency effort at *M.c.* eradication/containment was mobilized, based on an innovative, integrated strategy which has involved 1) helicopter spraying of herbicide as a holding action to limit seed production, especially in inaccessible sites beginning in early 1994; 2) development (1996-97) of access routes with a bulldozer to allow on-the-ground control; 3) hiring, beginning in June 1996, a locally-based 5-man crew, full time, charged with mechanical and chemical *M.c.* control; and 4) continuing public information and surveillance for new locations. Given stable funding to support the 5-man control crew for the next five years, we are guardedly optimistic for success in containing *M.c.*'s spread on Maui for the long term, especially if effective biocontrol can be developed. Sustained effort and success in locating and eliminating outliers will be crucial. The battle against *M.c.* has produced positive interagency links which are beginning to lead toward cooperative, coordinated efforts to exclude, eradicate, and/or manage other alien plant and animal species on Maui.

Maui est l'île de l'archipel hawaiien où les efforts pour combattre Miconia calvescens *ont été mobilisés en premier. Une alerte signalant la présence de* M.c. *sur Maui a été déclenchée pour la première fois en 1991, environ 20 après son introduction dans l'île. Cette alerte a été prise au sérieux (basée uniquement sur l'antécédent de la situation de* M.c. *à Tahiti) et une élimination des sept populations connues dans la région basse et sous-le-vent de East Maui a été entreprise, mais la capacité de dispersion de l'espèce avait été sous-estimée. À la fin 1993, quand un bilan plus complet du problème fut dressé, plusieurs milliers d'arbres en fruits étaient déja présents dans une zone relativement inaccessible (sur une coulée de lave âgée de 500 ans, au substrat accidenté) située au dessus de la population originelle. Pour répondre à la gravité de la menace, un effort multi-services afin d'éradiquer/de contenir* M.c. *a été mobilisé, basé sur une stratégie qui a impliquée 1) l'aspersion par hélicoptère d'herbicide comme action de soutien permettant de limiter la production de graines, en particulier dans les sites inaccessibles, dès le début 1994 ; 2) la construction (1996-97) de routes d'accès avec un bulldozer pour permettre une lutte sur le terrain ; 3) l'embauche (début juin 1996) à temps plein d'une équipe de 5 personnes basée sur place, chargée de lutter contre* M.c. *; et 4) la poursuite de l'information du public et la recherche de nouvelles localisations de* M.c. *Grâce à un financement stable permettant de payer l'équipe de lutte de 5 personnes pour les prochaines 5 années, nous sommes prudemment optimistes dans le succès de la limitation de l'extension de* M.c. *à Maui, particulièrement si une méthode efficace de contrôle biologique peut être développée. Le succès dans la localisation et l'élimination des individus isolés sera cruciale. La bataille contre* M.c. *a engendré des relations inter-services positives qui commencent à conduire à des efforts combinés pour exclure, éradiquer et/ou gérer de nombreuses autres espèces animales et végétales à Maui.*

In retrospect, we know that *Miconia calvescens* was introduced to the Hawaiian Islands about 1961 and has reached four islands -- O'ahu (1961), Hawai'i (early 1960s), Maui (early 1970s), and Kaua'i (late 1980s) (Medeiros *et al.*, 1997). We have also been told that after the late Pacific botanist F.R. Fosberg saw the developing infestation of *M.c.* on Tahiti in 1971, he warned Hawaiian botanists that "this is the one plant that could destroy Hawaiian rain forests" (F.R. Fosberg, pers. comm., 1991; Altonn 1991).

Why then was *M.c.* not listed as a Noxious Weed, illegal to sell or possess, under Chapter 68 of Hawai'i Statutes by the State of Hawai`i Department of Agriculture in Hawai'i until August 1992 ? One must assume that awareness of the threat from *M.c.* was not widespread among Hawaiian botanists, conservationists, and agricultural quarantine specialists. As recently as 1990, *M.c.* was not included as one of the 861 naturalized species receiving treatment in the authoritiative "Manual of the Flowering Plants of Hawai'i" (Wagner *et al.*, 1990). Several conservationists had expressed alarm in the 1980s at a spreading *M.c.* population at Onomea, north of Hilo, Hawai'i island (J. Davis, pers. comm.) and volunteer efforts to remove plants were mounted, but unfortunately the alarm did not prove contagious. The concern which has eventually led to statewide action was raised on the island of Maui in early 1991, about 20 years after its apparent introduction at Helani Gardens near Hana, Maui.

INITIATION OF *MICONIA CALVESCENS* CONTROL EFFORTS ON MAUI

National Park Service biologists, based at Haleakala National Park, became aware in 1990 that *M.c.* was present on windward East Maui, about 10 km from the Park boundary. Betsy Gagné, a Park employee who had seen the devastation caused by *M.c.* in Tahiti, noticed a single *M.c.* tree while driving past Ali'i Gardens, 10 km from the town of Hana. Gagné and Park biologist Lloyd Loope contacted the owner of Ali'i Gardens in January 1991, with the hope of eliminating the tree, which by then was surrounded by numerous saplings and seedlings. The highly cooperative owner of Ali'i Gardens destroyed the *M.c.* tree and provided information on the source of his tree -- Helani Gardens on the edge of Hana. Helani Gardens was found to have several dozen mature trees and thousands of saplings, but again, the landowner was cooperative and the problem seemed addressable. A presentation at the 17th Pacific Science Congress in Honolulu in May 1991 (Gagné *et al.,* 1992) and two newspaper accounts (Hurley, 1991; Altonn, 1991) expressed resolve in combating the problem on Maui.

Within the two years following discovery, seven *M.c.* populations were found, all within windward East Maui, but prospects seemed good for eradication because all were easily accessible. Over 20,000 plants were removed in 1991-93 from Helani Gardens and other sites, largely by National Park workers with assistance of volunteers. Scouting missions by foot into secondary forest just beyond the limits of Helani Gardens revealed scattered plants and groups of plants declining in number away from the garden, and the prognosis for winning the battle against *M.c.* seemed highly favorable.

However, the ability of the species for dispersal via birds had been underestimated. A much larger concentration of *M.c.* was discovered nearby during an aerial survey by state forester Robert Hobdy in September 1993. This population (hereafter referred to as the "Hana" population, after the district) already contained several thousand fruiting trees, based on aerial reconnaissance by Hobdy and Medeiros. There were several recognizable dense foci totaling 120 ha within a 1000 ha area upslope (100-350 m elevation) and west of Helani Gardens. The exceptionally rough terrain, underlain by a very young 500-year-old lava flow and thickly vegetated, had discouraged previous ground exploration, and continued to pose major problems for ground access. We realized for the first time that we were faced with

what was probably the largest and most rapidly spreading population of *M.c.* in the Hawaiian Islands.

Thus, a critical stage in the effort against *M.c.* on Maui (and in retrospect, in Hawai'i) was reached in late-1993. For the first time, it was clear that major resources would be required if there were to be any hope of eradicating or containing *M.c.* on Maui. But what to do? Initial reactions of desperation and discouragement by biologists and land managers stimulated a prompt and creative response.

COALESCING OF INTERAGENCY EFFORTS

In response to the severity of the threat, a multiagency effort at *M.c.* eradication was mobilized by the Melastome Action Committee and the East Maui Watershed Partnership.

The Melastome Action Committee (MAC) was formed in August 1991 through the initiative of R.A. Bartlett, conservation manager of the Maui Land and Pineapple Co., and E. Robello, the local representative of the Maui County Resource Conservation and Development Office of the U.S. Department of Agriculture. The Committee was formed to address the severe threats to conservation lands posed by plant species belonging to the Melastomataceae -- most notably *Tibouchina herbacea, Clidemia hirta*, and *M.c.*. *Tibouchina herbacea*, another highly invasive and ecosystem-dominating species, was first noted on West Maui in 1980 and had by 1991 come to dominate huge areas in the West Maui mountains managed by the Maui Land and Pineapple Company. *Clidemia hirta*, first noted in Hawai'i in 1940 and on Maui in 1976, has been recognized since the 1950s as one of Hawai'i's most damaging invasive species. The following state, private and federal entities have since met regularly since 1991: Hawai'i Department of Land and Natural Resources (DLNR), Hawai'i Department of Agriculture (HDOA), The Nature Conservancy (TNC), the University of Hawai'i, the National Park Service (NPS), the U.S. Forest Service, and (split off from NPS since November 1993) the Biological Resources Division of the U.S. Geological Survey (USGS/BRD). Activities of the Committee include public education, lobbying at the Hawai'i legislature and Maui County for funding for weed control programs, and planning, coordinating, and facilitating cooperative chemical, mechanical and biological control programs.

Whereas the Melastome Action Committee was established specifically to address the threat from invasive melastome weeds, including *M.c.*, the cooperative state-private-federal East Maui Watershed Partnership (EMWP) was formed in late-1991 with the goal of protecting watershed and biodiversity in windward East Maui "from non-native pest animals, weeds and other threats." EMWP members include DLNR, TNC, NPS, the East Maui Irrigation Company, Haleakala and Hana Ranches, and the County of Maui (represented by the Board of Water Supply). By late-1993, EMWP recognized *M.c.* as a major obstacle to accomplishing its mission.

The EMWP and MAC have worked jointly and effectively since late- 1993 to develop a strategy, obtain funds, and implement *M.c.* control on Maui. By the end of 1993, these two interagency groups had jointly adopted a strategy and presented it to a public meeting at Hana, Maui.

STRATEGY AND PROGRESS

The strategy against *M.c.*, first presented at the public meeting in Hana in December 1993, involves the following basic elements:

1) helicopter spraying of herbicide as a holding action to limit seed production, especially in inaccessible sites;
2) development of access routes to allow on-the-ground control;
3) mechanical/chemical removal by workers on the ground;
4) continuing public information and surveillance for new locations;
5) measures to prevent seed dispersal by "*Miconia* workers";
6) support for biological control; and
7) monitoring of progress.

These elements are described in more detail in Conant *et al*. (1997); the accounts below primarily provide updates since that article was prepared in early 1996.

1) Helicopter spraying of herbicide was implemented immediately as a holding action to limit seed production, beginning in early 1994. The release device for spot-spraying, attached below the Hughes 500-D helicopter by a cable, had been developed for use by local law-enforcement authorities in controlling marijuana cultivation in remote mountain areas. The herbicide (Garlon 4, ester formulation of triclopyr) was applied with surfactant and blue dye (Turfmark). The dye assists the pilot in judging application rate and identifying treated plants. As of late-1997, this strategy is still viewed as an important tool, especially in relatively innaccessible sites on cliff faces and steep slopes. Monitoring of effects of helicopter spraying of *M.c.* trees (n = 110 trees) in the Hana population with Garlon 4 in 1994 showed 72% of the trees killed and the remaining 28% of the trees with 69% defoliation and reduced fruiting after one year (A.C. Medeiros and C.G. Chimera, unpublished). Spraying of fruiting trees has proved effective as a holding action, but by opening the canopy, typically leads to abundant germination of soil seed banks of *M.c.*, and requires follow-up. Nevertheless, in spite of needed follow-up and the high cost of helicopter rental (ca. $850/hr), this method continues to be regarded as an important tool. As of late-1997, about 280 ha of the 1000 ha infestation have been treated at least once by spraying; the most densely-infested areas within this 280 ha have been sprayed repeatedly. Helicopter spraying is also envisioned as a tool for attacking individual outlier *M.c.* trees, detected within the forest canopy by monitoring from a helicopter, before they set seed.

2) Access routes were developed through rough lava terrain, overgrown with dense secondary vegetation, to allow on-the-ground control at the Hana *M.c.* population. A contracted bulldozer operator, supervised by Robert Hobdy of DLNR, opened the first road in early 1996. Within 18 months, 10 km of 4-wheel-drive roads were in place, subdividing the 1000 ha site into management units and allowing efficient access.

3) A Hana-based 5-man crew was hired in June 1996 and has been working full time to remove *M.c.* at the Hana population ever since. The motivation and effectiveness of this highly-motivated crew, supervised by Robert Hobdy of DLNR, is superb. They are pulling up saplings, cutting trees to large to pull up, and applying Garlon 4 herbicide to cut stumps. As of late-1997, it is foreseen that they will have systematically covered the entire 1000 ha *M.c.*-infested area once by June 1998.

4) Medeiros *et al*. (1997) mapped 10 Maui locations for *M.c.*, all on East Maui. Pat Bily of The Nature Conservancy has been successfully using public outreach/education within the East Maui communities of Keanae, Nahiku, and Huelo as a monitoring strategy to locate plants within known populations and to locate previously unknown invaded sites. The primary new location discovered within the past year was in Wailuku, a relatively dry area (mean

annual rainfall < 1000mm) between East and West Maui. A single planted tree had been removed around 1991, but several seedlings and saplings were found to persist in artificially-watered locations. All but two populations have been fully surveyed and all plants removed at least once. Some have been surveyed and plants removed a second time. The persistent seed bank, of course, necessitates continuing effort. Additionally, a number of isolated single trees have been located on East Maui, either the result of bird dispersal or of inadvertent (on boots?) human dispersal. Such isolated *M.c.* plants have been found as high as 600 m elevation and as much as 2.0 km from the nearest known population (P. Bily, pers. comm., 1997). These "outliers" (new populations?) provide cause for much concern and uncertainty.

5) No obvious problems have been noted in transfer to other sites of *M.c.* seeds in soil on the boots and equipment of crews engaged in control and assessment efforts. However, at this still early point in our efforts, it is difficult to assess the effectiveness of measures to prevent seed dispersal by "*Miconia* workers". Those working with *M.c.* are encouraged to wear conspicuously-marked footwear and other gear which are "dedicated," i.e. used only for work involving *M.c.*. Whenever bulldozers and other vehicles are used in *M.c.* areas, they are to be pressure washed immediately afterwards. The seed dispersal problem greatly complicates the issue of using volunteers. Whenever *M.c.* control is undertaken, a supervisor must be responsible for seeing that safeguards are taken seriously.

6) Biological control is regarded as a highly welcome adjunct to mechanical/chemical efforts, to reduce recovery potential through reduction in leaf growth and reproduction. In mid-November 1997, the fungus *Colletotrichum gloeosporoides* f. sp. *miconiae* (Killgore, Sugiyama and Barreto, this volume), which may prove to reduce vegetative growth of *M.c.*, was released by Dr. Eloise Killgore within the East Maui Hana population. Efforts are planned for the near future to bring a carposinid moth species, *Carposina bullata*, already tested and approved for release in Hawai'i, but not yet established in favorable habitats in Hawai'i, to the East Maui area (P. Conant, pers. comm.). The moth was originally investigated as a promising biocontrol agent for *Clidemia hirta*, upon whose flowers and fruits larvae feed; however, it was found to also attack many *Miconia* species in Trinidad, where *M.c.* is not present. We are hopeful that it will prove to attack *M.c.* as well. *Clidemia*, which is locally abundant on East Maui, not far from the *M.c.* populations, could serve as a primary host for the biocontrol agent even after *M.c.* populations have been largely eliminated. Establishment of insect biocontrol agents in Hawai'i has become notoriously difficult because of the accumulated establishment of a large diversity of alien generalist parasitoids. However, observations of the life history of the two moths in the field (R. Burkhart, pers. comm.) indicate that this larval moth should be protected from parasitism and predation through its feeding on the interior of reproductive parts of host plants.

7) We are committed to monitoring progress of control efforts as needed. The well-documented dynamics of *M.c.* re-establishment after removal within plots on Raiatea, French Polynesia (Meyer and Malet, 1997), suggests a minimum of 4-5 years from seed germination to fruit production; dynamics of East Maui *M.c.* populations closely resemble those found for Raiatea. Meanwhile, a feasibility study, by O'ahu-based TerraSystems, Inc., and the USDA Natural Resources and Conservation Service, will explore the effectiveness of spectral-sensitive aerial photography in detecting and mapping individual canopy trees of *M.c.*. The work is beginning in late-1997 and should be completed within one year.

Individuals of various agencies have stepped in to fill essential niches in the control effort. Major commitments are being made by DLNR (overseeing aerial herbicide application, development of access roads, and supervision of ground crews within the largest population, all by Robert Hobdy), TNC (eradication within peripheral populations), HDOA (logistical assistance with aerial herbicide application), and USGS/BRD (population mapping and monitoring effects of control).

CONCLUSIONS AND PROSPECTS FOR THE FUTURE

Hawai'i is the biological invasions capital of the United States and is in some ways in the forefront in confronting the problem (if not yet in effectively dealing with it). Lessons learned in Hawai'i are clearly highly relevant to other Pacific islands and perhaps to continental areas as well.

The Honolulu-based interagency Coordinating Group on Alien Pest Species is an alliance of biodiversity, agriculture, health, and business interests which has been working since 1995 to begin to seriously address the alien pest crises in the Hawaiian Islands (Holt 1996). A major public relations campaign was launched in late-1996 to increase public awareness of alien species problems (CGAPS, 1996).

Probably the most critical lacking element is a reasonably effective quarantine system -- better-funded, better-staffed, better-equipped, and better-legislated. Additionally, early detection and treatment of invaders before explosive spread occurs can potentially prevent many future problems.

As of late-1997, agencies and individuals on the island of Maui that have been working together at a grassroots level for six years to deal with the weed tree *M.c.* invasion envision evolution toward an interagency working group with subcommittees dealing with major categories of invaders. The group sees itself as a grassroots, single island based, component of Hawai'i's interagency Coordinating Group on Alien Pest Species. An island-wide plan would establish categories (exclusion, eradication, containment, large-scale management), and set priorities and responsibilities for pest management. The greatest challenge appears to involve obtaining funding and personnel to do the control work in an era of shrinking government. Is success possible? All agree that public education is a crucial ingredient of the anti-alien species strategy, to gain broad political support. Direct public involvement in selected eradication efforts is a useful tool. Publicizing success stories is an important formula for gaining support. Maui's successes and failures are likely to guide efforts statewide.

Approximately $500,000 have been committed to *M.c.* control on Maui since 1991. Efforts have intensified in 1996-97, and prospects appear favorable for a positive outcome although continued funding, commitment, and vigilance will be required. Given stable funding to support the 5-man control crew for the next five years, we foresee a chance of success in containing *M.c.*'s spread on Maui. Follow-up, possibly at a much reduced intensity, will be needed for at least an additional five years to deal with the declining seed bank. Ability to locate and eliminate outliers will be crucial to the effort. The prognosis for phasing out continual on-the-ground control effort depends to a great extent on establishment and effectiveness of the biocontrol agents and success in locating and eliminating outliers from the air, and we know that the latter is going to be very difficult. In other words, if everything goes extremely favorably and interagency effort is persistent, we have a chance to succeed.

What is the most potentially useful advice we can give Tahiti, French Polynesia, and other Pacific Islands? Watch out for *Clidemia hirta, Tibouchina herbacea*, and similar melastomes. *Tibouchina herbacea* reached Maui about 20 years and has exploded in pig-disturbed areas, first in West Maui and more recently in East Maui. Its dominance in extensive areas on Maui already rivals that of *M.c.* in Tahiti. Use the public's awareness of *M.c.* to publicize melastome threats. Ban importation of all members of the Melastomataceae.

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BIG ISLAND MELASTOME ACTION COMMITTEE: *MICONIA CALVESCENS* CONTROL PROGRAM OVERVIEW

LE COMITÉ D'ACTION CONTRE LES MÉLASTOMATACÉES DE LA BIG ISLAND : UN BILAN DU PROGRAMME DE LUTTE CONTRE MICONIA CALVESCENS

KIM TAVARES[1, 2]

[1]Cooperative National Park Resource Studies Unit, Botany Department, University of Hawai'i at Manoa, Honolulu, HAWAI'I (USA).
[2]Hawaii Department of Agriculture, 16 East Lanikaula Street, Hilo, HI 96720, HAWAI'I (USA).

The realization that *Miconia calvescens* posed a significant threat to the island of Hawai'i (the Big Island) was slow in coming. In fact, the species had been sold in nurseries for several years. Early efforts to control *M.c.* by the 4-H Club languished after the Hawaii Department of Agriculture declined to assist. Later, an interagency consortium developed a management program after a similar program on Maui demonstrated that containment of *M.c.* was possible. A number of mechanical and chemical control strategies are used. There are over 100 separate sites, individual infestation areas where flowering trees have been found, and are scattered over 100,000 acres. Control efforts focus on the distribution and mapping of the infestations, public awareness and education, and on the eliminating outlying satellite cores with the intention of stopping the spread into new unspoiled areas. Mapping efforts have been concentrated on roadways and in subdivisions, where *M.c.* have been reported by hotline callers and confirmed. Survey work in remote areas will soon be necessary as well. All types of media, news releases, televisions and newspapers, public meetings and slide presentations, and the flyers that have a picture and information about the plant and how to report sightings are all part of the public education process. All known satellite populations have had initial treatment done on their highest concentration cores.

La prise de conscience que Miconia calvescens *constitue une menace significative pour l'île de Hawai'i (la Big island) fut lente à venir. En fait, l'espèce était vendue dans les pépinières pendant de nombreuses années. Des efforts précoces pour lutter contre* M.c. *menés par le Club 4-H s 'étiolèrent après que le Départment d 'Agriculture de Hawaii ait decliné son aide. Plus tard, un consortium inter-services a développé un programme de gestion après qu'un programme similaire lancé à Maui montra que le contrôle de* M.c. *était possible. Un nombre de strategies de lutte mécaniques et chimiques ont été utilisées. Il y a plus de 100 sites différents, zones infestées particulières où des arbres en fleurs ont été trouvés, et dispersés sur 50 000 ha. Les efforts de lutte reposent sur la distribution et la cartographie des zones infestées, l'information et l'éducation du public, et l'élimination du centre des populations satellites isolées avec pour but de stopper l'extension dans de nouvelles zones non touchées. Les efforts de cartographie se sont concentrés sur les bords de routes et les subdivisions où* M.c. *a été signalé par téléphone sur la hotline et dont la position a été confirmée. Un travail d'inspection dans les zones isolées devra être bientôt nécessaire. De nombreux types de média, communiqués de presse, télévisions et journeaux, réunions publiques et présentations de diapositives, et des dépliants avec un dessin et des informations sur la plante et expliquant comment signaler les plantes aperçues, ont fait partie du processus d'éducation du public. Toutes les populations satellites connues ont été initialement traitées en leurs centres de plus grande concentration.*

Horticulturists brought *M.c.* to Hawai'i some time in the mid 1950's to '60's. It is unclear at this time whether the first plant was on O'ahu or on Hawai'i, both islands report the possible presence of *M.c.* during that time. It was thought of as an attractive ornamental plant with spectacular foliage. The plant is native to Central and South America, where climatic conditions are much like those in Hawai'i. This species adapted well to it's new

environment, moisture was abundant and there were no apparent natural enemies. A report from a Hilo resident, Kay Nishioka, on the island of Hawai'i (the Big Island) places the plant on the island some time between 1955 and 1959 (Nelson Ho, pers. comm., 1998). A second report on the Big Island, from caretakers at the Volcano Store (pers. comm., 1997) have potted *M.c.* plants in Volcano in 1959 but *M.c.* has not been seen there during recent surveys. The first occurrence of *M.c.* from O'ahu data suggested a tree in Wahiawa Botanical Gardens in the early '60's, possibly as early as 1961 (Conant and Nagai, this volume).

There are few records between 1965 and 1975, although it is apparent the original plants were left to grow into trees. By the early to mid 1970's nurserymen propagated *M.c.* for sale and distribution, especially on the Big Island. Commercial sales continued for several more years, and previously planted trees matured. The Big Island was under a silent attack and the public still had no idea. Young trees emerged as far away as 400m from the mother trees, and hundreds and perhaps thousands of hectares of land were being contaminated. Satellite *M.c.* populations emerged from nearly 100 confirmed locations across the Big Island.

M.c. is a major threat to the forests of the Big Island because the island's rural and undeveloped lands are so widespread with subdivisions and nurseries near native forests. *M.c.* was transported around Hilo, into Puna, and across the island to Kona. *Anthurium* blight may have been an indirect contributor to the spread of *M.c.* as well. In the 1980's many flower farms were hit with the disease and abandoned. Some of these farmers were propagating *M.c.*, and others were believed to have cinder potting mixes that were brought from other *M.c.* contaminated areas. Many of the abandoned farms are infested with saplings and seedlings numbering in the thousands. The plants are now in much more remote areas, places where people rarely go.

Today it is believed that most locations with intentionally planted *M.c.* have been rediscovered on the island of Hawai'i. In many locations the original trees were destroyed several years ago. All that remain are their offspring, some now mature. Hundreds or thousands of young plants are commonly found at these sites. The contaminated areas range in size from a very compact 10 meters around an individual matured tree, to large parcels of 250 hectares or greater. In the steep gulches of North Hilo, *M.c.* has been spread upstream by birds traveling along it's course.

EARLY EFFORTS

Information gathered from many Big Island residents led to the conclusion that most intentional plantings occurred from the early 1970's to mid '80's. By 1982, *M.c.* seedlings were considered a nuisance in many of the originally planted locations. Kay Nishioka noticed *M.c.* scattered throughout the Hirose Nursery property in Hilo and being concerned what could become of her yard, she was alarmed. By June of 1982 she had the tree destroyed, but not before many seedlings emerged.

Joyce Davis, a botanist with Hawaii Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW), was also searching for information on the plant. In September of 1982 Ms. Davis received a response to an inquiry to the National Museum of Natural History - Smithsonian Institution. F.R. Fosberg, who had personally seen the long-term results of this very same problem in a recent trip to Tahiti, recommended immediate action : "it makes the most dense shade I have ever seen in a forest. The combination of dark green and dark purple in the leaves lets almost no light through. Its own seedlings are about all that can grow under a dense stand of it".

Ms. Davis launched a public awareness campaign to alert more people of the need to control this pest weed. She displayed live *M.c.* specimens at the Hawaii County Fair in September of 1982. A new satellite population was being established in the undeveloped forest lots on the block of Mamaki and Awa streets in Panaewa. She destroyed the plant. Elsewhere around Hilo town people with mature trees were beginning to note the abundant reproduction. They were among the first to destroy the mature trees in their yards but not before seeds were already scattered by birds.

Kay Nishioka, also working for DLNR at the time as well as being an active volunteer for the 4-H Club, decided to form a work detail to battle *M.c.*. The Cougars 4-H Club distributed letters explaining *M.c.* as a bad pest, and requested distribution information and general help in the destruction process. In October 1982 an article in the Hawaii Tribune Herald announced the start of the *M.c.* plant eradication program by this group. A thousand mature trees and several thousand seedlings were destroyed or at least set back several seasons. Cutting trees was the most common control method, herbicides were sometimes used on the stumps but many resprouted.

In February 1983 a letter was written to Jack Suwa, Chairman of the Hawaii State Board of Agriculture, expressing their concerns. In response they were informed that considerations were being made to place *M.c.* and all melastomes on the Department's Noxious Weed List, as a "potential pest of our environment". In June, another work trip, this time to the Carlsmith property above Onomea Bay, was conducted. The largest trees then measured 15cm basal diameter, however the majority ranged between 5cm and 10cm. More effective control methods and a strategy were needed as the problem was beyond their control. The State of Hawaii Department of Agriculture (HDOA) took note of the location, visited the site but left it alone because *M.c.* was not on the Noxious Weed List yet. It didn't appear to be a problem big enough to warrant concern, and the 4-H Club was handling it. By 1984, 4-H work stopped, overwhelmed by the scope of the infestation. She presented the problem to the Board of Agriculture once again and strongly recommended immediate attention. No work was recorded on the Big Island for the eight-year period following the last 4-H Club efforts, from 1984 until 1992.

Statewide efforts combined to create a full-color poster with photographs and information about the problem and what to do. It was prepared by the Conservation Council for Hawaii, the Noxious Plants Task Force, Betsy H. Gagné and Steven L. Montgomery, in coordination with the Committee on Introduced Species. Support for the preparation of the poster was provided by DLNR-DOFAW, Hawaiian Botanical Society, Waimea Arboretum Foundation, Sierra Club Hawaii Chapter and Maui Group, National Audubon Society and Hawaii Audubon Society. A photograph of a *M.c.* tree and close-up images of leaves and fruit were printed on the cover along with information about the destruction it could cause, what to do and who to call if *M.c.* were found. These posters and subsequent printings have produced many reports by the public. Much of the initial location data throughout the islands was generated from this endeavor.

In 1992 HDOA resumed considering *M.c.* as a candidate to the Noxious Weed List, and as time was available, crews on the Big Island resumed control work at all of the previously known sites. Mature stands were cut back in several locations. HDOA crews worked along the Belt Highway from Onomea to Papaikou, in Hilo town to Panaewa and to Waiakea Uka, destroying mature trees. They responded to telephone reports from the public and charted the new information. Work also began in Puna at several satellite populations. Mature trees were destroyed in a large infestation at Leilani Estates on Kupono St., at Ainaloa from Coconut to Pearl, in Nanawale and in Kurtistown cane fields. Some trees were also destroyed in the Kona district. It was a productive start that lasted only three months. A conflict with a property owner caused the crews to discontinue control work on private programs. In July, researchers of the Haleakala National Park (HALE) contributed another $15K to support the continued research of chemical treatments and methods of

destruction and, by August, *M.c.* was placed on the Noxious Weed List. HDOA was now mandated to take action.

Three significant events occurred in 1993 along with continued public education and monitoring. Jean-Yves Meyer of Tahiti visited Maui. His interest in the *M.c.* problem of Tahiti and the news of it beginning in Hawai'i brought him to the Islands to contribute his knowledge and recruit help in finding a solution that could spare what was left of the Tahitian forests, as well as those in Hawai'i. In a helicopter survey of some State forests, Robert Hobdy, a forester for DLNR discovered a large population of *M.c.* above Hana, in a remote area well away from roads and homes. He estimated a core of 1ha in size. This increased the magnitude of the Hana site considerably, increasing the estimated core size to an estimated at 7ha, with satellite populations scattered throughout 18ha of forest (Randy Bartlett, pers. comm., 1997). And also in 1993 the Maui MAC received a grant of $97,000 for biological control research and public education on melastomes.

Randy Bartlett, as spokesperson for MAC, presented information to lead agency representatives of the State and Federal governments. Another meeting was called on the Big Island to relay the new information and to form the Big Island Miconia Action Committee (BIMAC). The committee applied for and received a $6,000 grant from the County Council.

DEVELOPMENT OF THE CURRENT CONTROL CAMPAIGN

Statewide *M.c.* awareness advanced considerably in 1995. Several activities were sponsored and organized and many *M.c.* sightings were reported. School children as well as adults were learning of the danger, and assisted in locating and destroying the pest. Many new sightings were recorded, one of them from Kaua'i, the fourth Hawaiian island infested with this pest. A single naturalized population was discovered there from a tree planted in a botanical garden. On O'ahu, the Sierra Club joined control efforts led by Patrick Conant, HDOA, enlisted the help of volunteers to scout for and uproot seedlings in contaminated gullies on the southern side of the Koolau mountain range, from Kalihi to Manoa Valleys (Conant and Nagai, this volume).

Efforts increased on the Big Island using the County $6,000 funding. The Hawaii Resource Conservation and Development Committee hired Sheri Amundsen of Maptech, Inc. to survey and map *M.c.* distribution in lower Puna. Additionally, a "*Miconia* Hotline" telephone was installed. Several hundred calls came in during the first year the line was placed in service. Each sighting report was recorded and drive-by verifications were made throughout lower Puna and in Hilo. Each confirmed sight was recorded in the global information satellite (GIS) location database. BIMAC obtained the information it needed to organize the next step in the plan, the hiring of a full-time *Miconia* control team.

Also in 1995, additional funding and resources from US Forest Service, HDOA, and University of Hawaii continued the search for biological control agents. USFS contributed $8,000, and $113,400 came from the State through HDOA funds. Control efforts and public education were also supported by these funds.

By December of 1996, the Big Island had a full time three person team in operation, fully functional and funded for six months. The team began responding to hotline calls from the prior year, visiting callers to confirm sightings and destroying any trees found. Information gathered was recorded on maps so the infested parcels could be identified and the owners contacted. Helicopter flights were utilized to survey remote areas around known populations. US Geological Survey-Biological Ressource Division (USGS-BRD) at HAVO contributed $10,000 in helicopter reconnaissance charter time. DLNR-DOFAW provided $30,000 in field crew time to assist with the control efforts.

Governor Cayetano launched the statewide campaign "Operation *Miconia*", in March of 1996, supporting the efforts. The Nature Conservancy (TNC) contributed $50,000 to a technological research effort in spectral analysis. A three-year grant of $70,000 per year was also awarded in 1996 to fund biological control research and monitoring. By 1997, the statewide campaign to battle *M.c.* was well under way on all islands. Field crews destroyed thousands of mature trees buying time for the biological control researchers to develop the ultimate solution.

ACTIVITIES OF THE CURRENT BIMAC PROGRAM

Encouraged by the success of the initial contract with the County, BIMAC requested additional funding. They obtained $100,000 to continue the effort on the Big Island. The funds were used to leverage additional grants from other agencies. The USFS contributed $50,000 and the National Fish and Wildlife Foundation (NFWF) provided $25,000 through the "Pulling Together Initiative". Another grant from the National Park Service "Challenge Cost Share" program afforded the team an additional $29,000 for personnel support. New partners joined BIMAC in 1997 and 1998 to assist and support the program. MLS Hawaii, Inc., a private company, has donated access to their data base which gives the team vital property ownership information. The team can now quickly and easily determine who and where the property owners are and establish contact with them. The Estate of James Campbell, a private company and large parcel landowner, has donated $10,000 to support control efforts. Alu Like is another federally funded partner. Another large landowner, Kamehameha Schools/Bishop Estate, has recently joined BIMAC meetings to obtain more information and to assist in the future success of the program.

With a full-time team in the field a few significant facts were quickly established. People were the primary dispersal agents, the earliest known trees were by houses or other buildings. Nearly 100 satellite populations were discovered from sea level to 800m elevation on the Big Island, mostly along the eastern and south eastern coast of the island. Two populations were also discovered on the west coast of the island in the Kona district, and a third has been reported but not yet confirmed. Control efforts were focused initially on these satellites, working from the outside, towards the core populations of Hilo. Dense stands of mature *M.c.* were treated first. BIMAC organized a systematic approach to the problem.

BIMAC MAPPING AND DATA TRACKING

Early *M.c.* introductions were near sea level, consequently the incidence of mature trees were greatest in this area, approximately 3,000 trees per ha in the more concentrated sites. Because *M.c.* was used in landscape plantings, sightings of roadside plants were used successfully in targeting mature, flowering trees nearby. Generally, tree densities lessened with increasing elevation. Early mappings shows 1,250 mature trees per ha at satellite populations in the 185m to 450m elevation range, and 250 (or less) mature trees par ha, at satellite populations in elevations above 450m.

The field team has been recording distribution information with as much detail as possible. When a site with a mature tree (or trees) is confirmed, information is collected regarding property ownership and occupancy. Locations are recorded on road maps or hand drawn maps, the information is then processed to determine the plat and parcels that are affected. The Real Property Tax Office of the County of Hawaii maintains ownership parcel maps for tax purposes. Parcel maps and a data base contain information on parcel acreage, dimensions, ownership and occupancy. These maps are currently the best method of monitoring *M.c.* because they offer convenient tracking information. Individual properties can be determined and individual flowering trees can be accurately plotted within the parcels on these maps. The most detailed map, known as the "plat", has been divided into individual parcels and each parcel has a unique number known as its "TMK". Work files are created for each affected plat. Our files contain a copy of the map and all information regarding the

affected parcels. Records of control access requests, control work dates and plant quantities and sizes, correspondence and any other information are stored in these work files.

Fig. 1. *M.c.* distribution on the island of Hawai'i (Big island)

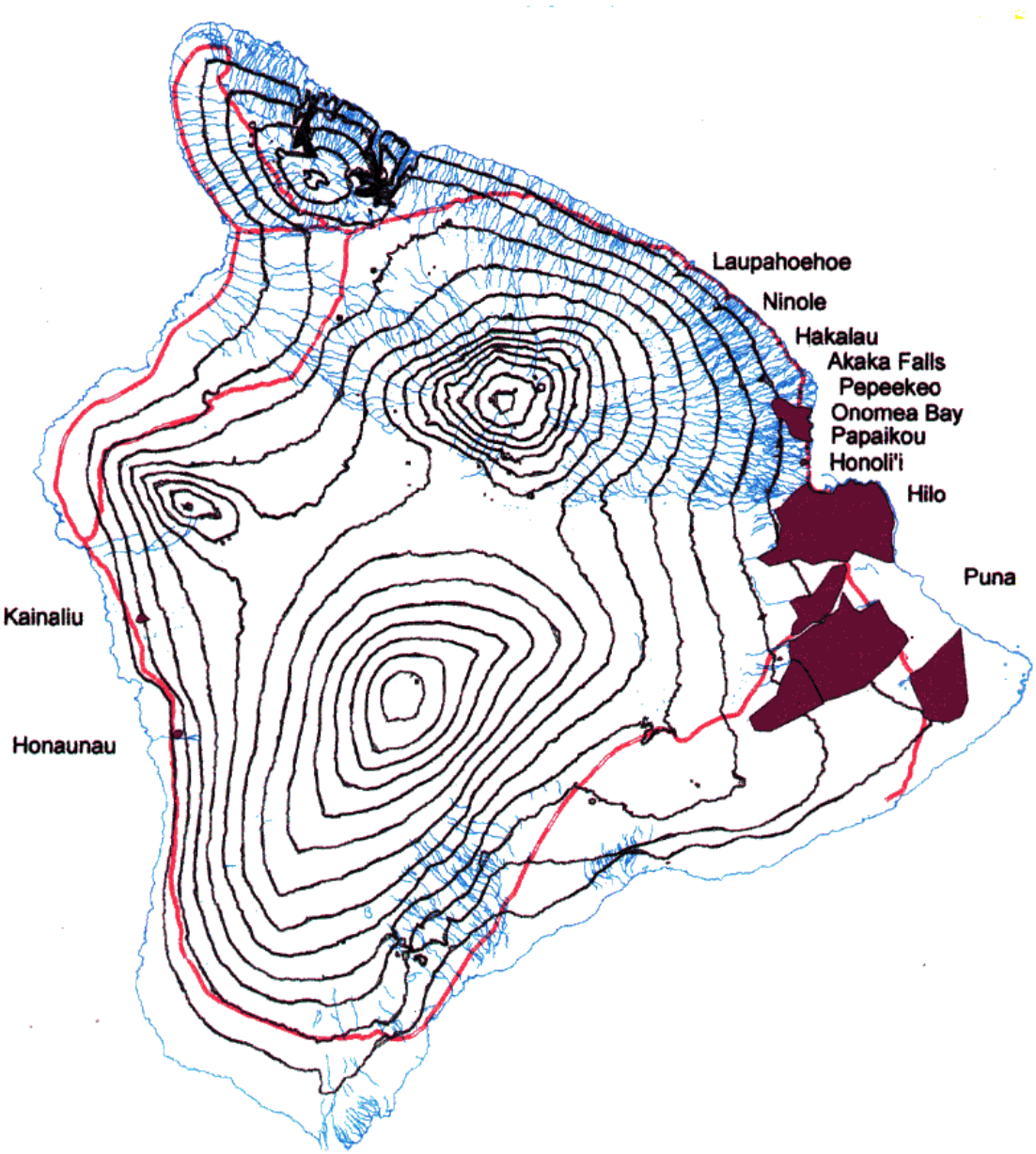
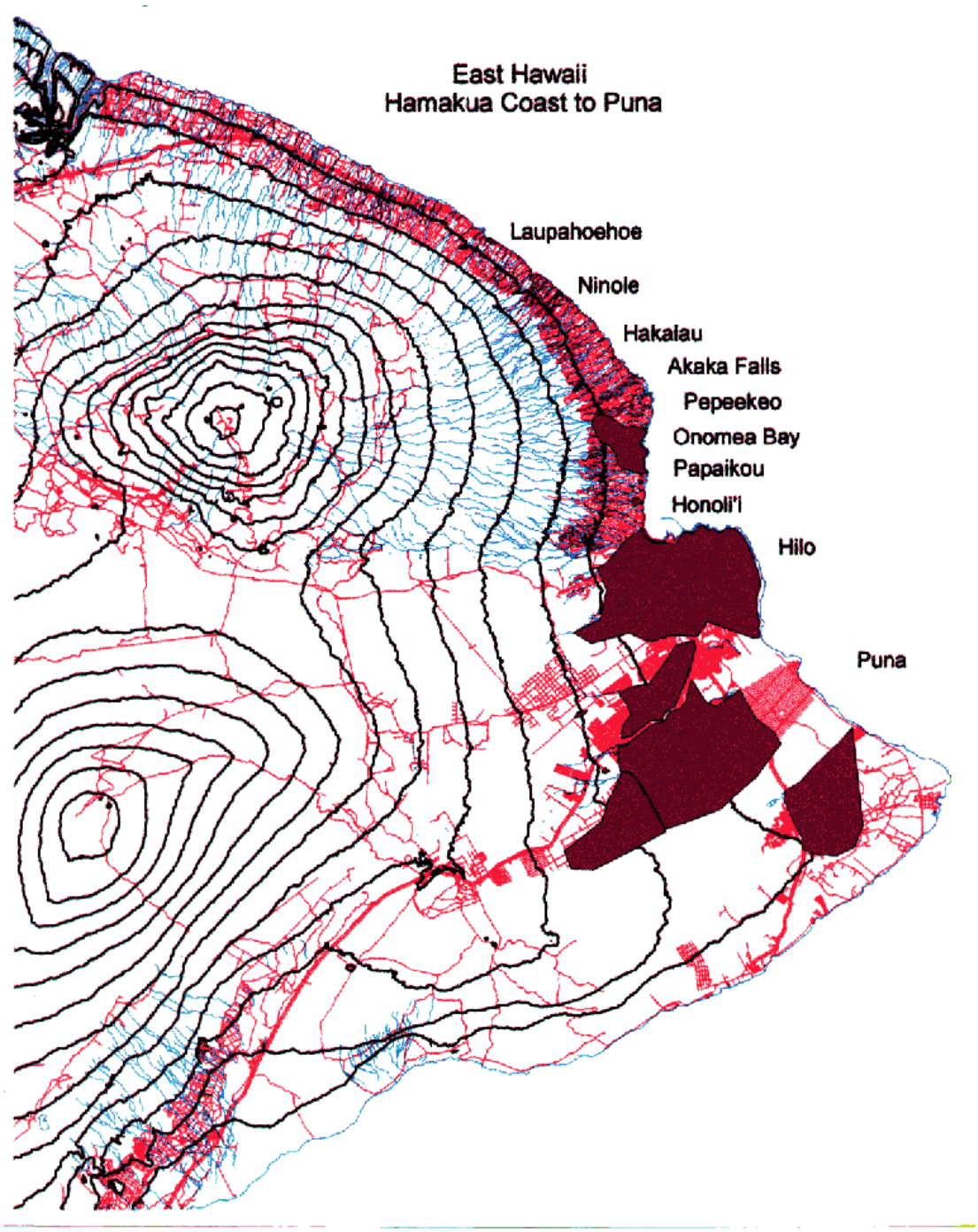


Fig. 2. *M.c.* distribution on East Hawai'i : Hamakua Coast to Puna



To get a better overall picture of the problem known *M.c.* locations have also been recorded on US Geological Survey quadrangle maps (1:24,000). These maps are primarily used in planning surveys and control strategies. They provide an overall picture of the infestations and areas at risk. Aerial photographs are also used for more refined plotting and to show features not included on quad maps.

A wall-sized map with *M.c.* locations and management units was produced. *M.c.* locations were marked, and unit boundaries were defined around groups of identified and potential sites. Twenty seven management units were created. Surveys have since concluded that five of these units are free from *M.c.* The original reports were most likely plant identification errors. Indian Rubber (*Ficus elastica*) trees are commonly mistaken as *M.c.* These units will continue to be surveyed annually as a precaution. This wall map is used to display the problem in an island-wide context and is frequently referred to in strategy discussions. It is also used as a visual aid for public education and has been reproduced on color slide film and shown during presentations.

Digitized maps are being developed and will be extremely useful when plotting the precise locations of remote plants. All *M.c.* found on helicopter surveys are marked by global positioning satellite receivers. These coordinates are downloaded to a data base and can be seen in an overlay on a digitized USGS quad map. Sites along the westernmost boundaries will be among the first to be plotted. It will aid in the planning of survey work and will be the baseline for all control efforts.

Once digitized, distribution and control information can be analyzed in any number of ways and used as a tool to monitor control efforts. This will also allow the information to be more widely circulated for reporting and presentation purposes as well as in an ".html" format for posting on the "www". Federal cooperators have hardware and software to do the work and are in the process of recording the data in GIS format.

The "*Miconia* Hotline" is still being monitored and new reports verified by the team. These calls continue to be a good source of information as well as a way to inform callers of the progress of the program. Hotline calls are logged onto a form, the callers get answers to their questions, and meetings are scheduled to verify the sightings.

Surveys continue through all the subdivisions, towns, and other roadways that are within range of known *M.c.* infestations. Although it is believed that most locations visible to the public have been reported, it is also believed that many remote populations have not been located. Remote areas are surveyed by air. Helicopters are the most effective means of surveys in remote areas without roads. From the air large infestations can be spotted easily. We do not expect to find large contiguous populations of mature trees. Unfortunately, helicopter overflights are not appreciated in most developed areas, so most surveys in rural subdivisions will have to be completed from the ground.

Another important item to consider is that flying over an area will not necessarily reveal all *M.c.*, only the ones large enough to be detected through the surrounding vegetation. Once an area has been surveyed by air, it should be monitored annually for several years to be sure that no smaller trees are growing and becoming mature. Hunters have reported *M.c.* in North Hilo forests. These reports need follow up on foot as many of these areas have already been flown without sighting large *M.c.*

CURRENT CONTROL EFFORTS ON THE BIG ISLAND

A full-time control effort has been operating on the Big Island, beginning at the most remote locations. Larger crews from DLNR-DOFAW have been available on a part-time basis for treating larger populations. Once the core populations were destroyed, work began

in the buffer areas around each core. Control lines were set up around the infested locations to begin measuring the extent of the infestation from the core outward and to structure the field work into easily managed blocks. With assistance from the forestry crews, the team is able to cover much more ground in less time. There are over 100 individual work sites to attack and several remote area reports to be checked.

The first hired member of the team was responsible for strategic planning, tactics, logistics, records, public awareness and daily crew functions. A weed control technician now leads the field staff and temporary personnel resources at the scheduled work sites. Another technician has also been with the team since it's inception. The public awareness coordinator has been surveying subdivisions and speaking with residents throughout the infested districts since May 1997. There is funding to carry this four person team through May 1998.

In July the team was awarded federal "Challenge" money which allowed the team two more workers for six months. One position was dedicated to enhancing the field team with an experienced weed controller and the other for public awareness. The latter conduct road-side surveys, makes door-to-door contacts to inform residents of *M.c.* and gathers information. The historical information obtained is important in reconstructing the introduction of *M.c.* into new areas and in tracking down the locations of parent trees.

Satellite populations have been reduced significantly and the crews are closing in on core populations. High elevation satellite populations nearest the forest reserves have been treated first. In upper Puna, *M.c.* occurred up to the 800m elevation level. The field team is currently setting up large blocks of work in preparation of additional control workers. DLNR forestry crews are scheduled to work with the team one to two weeks per month. With a crew size of six to eight persons large parcels can be controlled efficiently by systematically walking thorough them. Workers side by side, equal distance apart, and within sight of each other, can sweep an entire parcel from one end to the other leaving no piece of the parcel uninspected. Additionally, the team has incorporated the use of portable stands to hold an informational sign near the equipment and vehicles on the roadsides. This tells the local traffic and pedestrians that *M.c.* work is being conducted.

CONTROL METHODS

Currently field crews use chemical and mechanical. It is challenging, resource-intensive but essential work that in conjunction with successful biological controls should prove to be a winning combination in the battle against the weed. Chemical and mechanical control methods have evolved during the control effort. Young plants can be effectively controlled during dry weather by pulling them and hanging them in surrounding vegetation to desiccate. During the rainy season young plants have been found sprouting new roots from the entire main stem on plants up to 30cm in height, without being in contact with soil six weeks after being uprooted. Dense populations of seedlings may also be effectively and efficiently controlled with foliar application of herbicide. Current practice in dense stands is to control mature and near-mature trees, with follow up in three to four months to assess results. By then the herbicide should have taken effect and newly emerging plant densities can be evaluated for future control. In areas that have scattered *M.c.* all plants are destroyed regardless of age.

Plants too large to uproot require herbicide treatment to prevent resprouting. Several methods have been found effective as long as treatment guidelines are correctly implemented and all stems are treated with herbicide. Cut stump and frill and squirt methods have been the standard methods for destroying large *M.c.* on the Big Island. With the cut stump method, the entire stem is severed from the stump. The stump is immediately treated with herbicide, and care taken to treat all of the exposed cambium. With the frill and

squirt method, the bark of large trees is frilled with angling cuts into the cambium of the main stem. A series of cuts are made around the entire circumference. Herbicide is then squirted into the frills. The success of both methods is dependent on thoroughly treating the full circumference of the tree according to label requirements of the herbicide. Best control with these methods has been with undiluted Garlon-4, active ingredient triclopyr. Post treatment surveys have located numerous sprouting stumps after these treatments. We suspect that many of these are the result of missed application after the trees were cut. Some may also be due to inadequate treatment of the cambium. Rain may have been a factor. We have now started using long-lasting dyes in the herbicide mix to quickly ascertain whether stems have been treated.

Field trials with low volume and thin-line basal applications of Remedy or Garlon-4, both containing the active ingredient triclopyr, have been encouraging. In the fall of 1997, low volume basal application with 20% Remedy or Garlon-4 in diesel oil was adopted as a standard control method. Bas-Oil Red dye is used in the herbicide mix to allow quick visual confirmation of treatment. This method has the benefit that the tree does not have to be cut. Only the base of the tree is sprayed with the herbicide allowing fast and effective treatment. Again it is essential that the entire circumference of the tree be treated. Field trials have shown that this method is very effective on all sizes of plants, it is effective even in light to moderate rainfall. Further trials are needed for safe and effective pre-emergent control of seedlings and for foliar control of trees on steep banks and other locations where access to the base is difficult.

PUBLIC AWARENESS AND EDUCATION

Through many types of public awareness activities and information resources, the *Miconia* Control Program has increased in motivation and strength by the number of individuals, businesses, organizations, and agencies who support the program. The program does not exist in one agency alone. The responsibility is shared by many. Continued support of all kinds will be necessary for several more years to completely remove this threat once and for all.

Community outreach is aimed at presenting effective information to those who are in or who own threatened areas and to any other interested persons. Presentations including slide shows, detailed maps, and sometimes a fresh specimen for examination are presented to communities and groups. Local status reports for individual communities are submitted to the editors of community newsletters, encouraging members to keep a watchful eye in their areas. It also alerts residents to known areas within their communities where *M.c.* have already been found.

Road surveys have produced evidence that not all people have been informed of the threat. Some people are still growing *M.c.*. In other cases people are finding seedlings in their properties and assume that once uprooted, the problem is gone. As people within the community realize that they have this particular problem, they talk among themselves and if there are more plants they are soon reported to the team.

Personal contacts during road surveys have been an effective way to educate the public. When there is a need to survey a certain area, the team goes road-by-road, door-to-door, speaking to as many people as possible. Informational posters with colored photographs of the plant, information about the problem and a phone number to report a finding are handed out. A fresh sample of a real plant is also carried since identifying it by a photo is often difficult. In some suspect areas that have no reported sightings, posters with pictures and fresh samples are displayed in public areas. In many cases someone will recognize it and call the hotline to report it.

Informational meetings and presentations during regular business meetings give the field team the opportunity to encourage participation and volunteer efforts from groups as well as giving the group an updated report on the status of the control program. Acceptance by the community is important and becoming familiar with the field team gives them comfort in knowing what is happening and who the people are around them.

Keakealani Outdoor Education Center (KOEC) in Volcano Village teaches students and teachers alike about the dangers of alien invasions and makes special effort to focus on *M.c.*. Display boards with photos, information and slide shows are presented. Many students are inspired to study it more, creating science projects and volunteering to help the team. Many of the reports to the hotline are from students who have learned of the problem in school or at excursions to KOEC. Educators from around the state have learned of this threat from KOEC. Some have gone into the field to experience it for themselves and to share the important lessons that were learned about the environment.

Information dissemination is also carried out in other social functions and forms of media. Display boards and literature are brought by the team to fairs and other gatherings. Presence at these functions gives the public the opportunity to learn more about the problem, what is being done and what they can do to help. Information is also presented on television. A film producer on Maui created a selection of informational, 30-second, film footage of people destroying the plants with phone numbers to call for more information or to report sightings. News reporters have incorporated *M.c.* into their reports on the environment, newspapers and magazines are doing the same. BIMAC has submitted press releases to the local newspapers, radio and television stations, reporting new funding sources, status and current plans of the attack.

Community action groups have been organized. Some communities are assisting in the control work for their areas. Early control efforts were done in the Puna subdivisions of Nanawale and Leilani Estates. Leilani Estates has been diligent in requesting participation by their members and have also contributed funds to purchase the necessary herbicides. Concerned residents in Fern Acres and Fern Forest have helped to reduce the threat in their area as well. Organizations such as the Outdoor Circle and the Rotary Clubs have also participated in eradication projects, as well as individual and family efforts around peoples homes.

The team is currently organizing a training program for groups of interested people who wish to assist in the project. They present it to all new workers whether funded or volunteer. The need to understand the problem of dispersal and prevention of contamination, knowledge of things to watch out for and other safety issues for field work will are taught. With proper coordination and training, *M.c.* can be controlled by volunteer efforts in some locations. Ideally, a group could ‘adopt’ a favorite site, monitor it and control it at least annually. They can refer to the team for guidance, support, and in some cases supplies. Team members be scheduled to accompany them at sites until such time their leadership is not necessary. The team will monitor the sites annually and reports will be generated to reflect progress.

DISCUSSION

M.c. is present on four of the Hawaiian Islands, i.e., Hawai’i, Maui, O’ahu, and Kaua’i (Medeiros *et al.* , 1997). Of all of these islands, Hawaii - The Big Island, is the largest (the rest of the island chain combined covers less area) and has the most serious problem. With 10,433 sq km of land, much of it covered by dense remote rainforests, it appeared there would never be enough financing for the entire program. *M.c.* was already naturalized in several places near remote forests and something had to be done immediately.

Maui land managers discovered their problem by chance, from the air, and were quick to respond. O'ahu and Kaua'i had a few small populations (Conant and Nagai, this volume). Only the Big Island had so many separate populations. As long as any island has *M.c.*, the other islands are vulnerable. People on the Big Island were already helping to move it around the island from place to place. In a pot it is easy to intercept as long as there are agricultural checks between islands before flights but inspectors can't stop people wearing muddy shoes. Or carrying that special pair of hiking boots that they never travel without for that matter. *M.c.* seeds are very small (Meyer, 1996). Anyone walking beneath a *M.c.* canopy or old site could carry seeds in their hair, on their clothes, or on equipment from one place to another. Hapu'u (*Cibotium spp.)* fiber is another source of new infestations.

Finally Big Island resource managers took action. Convinced by those on Maui that *M.c.* could still be controlled and that forming a partnership now was necessary, as well as possible and not too late an effort, BIMAC was formed and a team was hired. The problem was a great challenge due to the size of the island and the size of area infested. Other problems encountered were difficult terrain, steep slopes, and thick vegetation. The number of owners with *M.c.* infested land is in the thousands. All of them had to be notified and willing to cooperate. With limited funding, the team needed to act fast, be efficient and keep the campaign alive in the minds of the public. The help of all agencies is necessary.

Maui resource managers had a much easier time because the problem was recognized much earlier than on the Big Island. This early action prevented more land from being infested. They were also fortunate to have the worst situation on a parcel of State land, where the work could be done without contacting many owners.

As stated by Randy Bartlett, motivating force of the Big Island committee, "The lifeblood of our State's economy is not Tourism, as those in the Tourism industry would have you believe, it is our environment. People travel here to enjoy our unique environment with its wonderful weather. Everyone in the state depends on our native rainforests to provide the watershed capacity to fulfill our potable & agricultural water needs".

All of the urgency is necessary, the best possible control by chemical, mechanical, and biological means must continue, until more effective methods are found. Researchers and scientists are hard at work searching for natural enemies to help control this pest (Killgore, Sugiyama and Barreto, this volume). The answer to stopping the spread is by people using labor intensive and time-consuming methods. The answer to total eradication lies with some sort of natural enemy to continue working even when people stop to rest. Some hopeful signs are already on the horizon but they will take several years to develop.

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APPENDIX : PARTICIPANTS AND SUPPORTERS OF OPERATION *MICONIA* IN HAWAI'I

Federal Agencies

BRD	Biological Resources Division
HALE	Haleakala National Park
HAVO	Hawaii Volcanoes National Park
NBS	National Biological Survey
NFWF	National Fish and Wildlife Foundation
NPS	National Park Service
RM	Resources Management Division
USFS	Unites States Forest Service
USGS	United States Geological Survey

State Agencies

DLNR	Hawaii Department of Land and Natural Resources
DOFAW	Division of Forestry and Wildlife
HDOA	Hawaii Department of Agriculture
KOEC	Keakealani Outdoor Education Center
UH	University of Hawai'i at Manoa

County Involvement

	Hawaii County Council
	Hawaii County Office of Research and Development
	Maui County Council

Other Involved Organizations & Individuals

BIMAC	Big Island Miconia (Melastome) Action Committee
	Cougars 4-H Club
	Donn Carlsmith, Onomea property owner
EWMP	East Maui Watershed Partnership
	Hawaii Resource Conservation and Development Committee
	Maptech, Inc.
MAC	Melastome Action Committee - Maui
RCUH	Research Corporation of the University of Hawai'i
	Sierra Club Hawaii Chapter
TNCH	The Nature Conservancy of Hawaii
Tri-Isle RC&D	Tri-Isle Resource Conservation & Development Committee

PROSPECTIVE BIOLOGICAL CONTROL OF *MICONIA CALVESCENS* IN HAWAI'I WITH A NON-INDIGENOUS FUNGUS *COLLETOTRICHUM GLOEOSPORIOIDES* (PENZ.) SACC. F.SP. *MICONIAE*

PERSPECTIVES DE LUTTE BIOLOGIQUE CONTRE MICONIA CALVESCENS *A HAWAI'I AVEC UN CHAMPIGNON NON-INDIGENE* COLLETOTRICHUM GLOEOSPORIOIDES *(PENZ.) SACC. F.SP.* MICONIAE

E. M. KILLGORE[1], L. S. SUGIYAMA[1] AND R. BARRETO[2]

[1]Biological Control Section, Hawaii Department of Agriculture, 1428 South King Street, Honolulu, HI 96814, HAWAI'I (USA).
[2]Departamento de Fitopatologia, Universidade Federal De Vigosa, Vigosa, MG 36570-000, BRAZIL.

Host range tests of a fungal pathogen from Brazil, identified as *Colletotrichum gloeosporioides* (Penz.) Sacc. f. sp. *miconiae*, were concluded at the Hawaii Department of Agriculture's Plant Pathology Quarantine Facility in December 1996. Of nine different genera within the family Melastomataceae and 13 genera and 17 species representing other members of the families of the Myrtales, only *M.c.* was susceptible to infection by this pathogen. *C. gloeosporioides miconiae* causes anthracnose type of leaf spots followed by premature defoliation of *M.c*. When the pathogen is inoculated onto injured stems, cankers develop causing a dieback of the branch. The disease is disseminated via spores or conidia that are produced in fruiting structures called acervuli. Free moisture is required for sporulation as well as for germination of the conidia, hence, this biocontrol pathogen is expected to be most effective in wet and windy areas.

Des tests de spécificité à l'hôte utilisant un agent pathogène fongique provenant du Brésil, identifié comme Colletotrichum gloeosporioides *(Penz.) Sacc. f. sp.* miconiae*, ont été effectués dans le laboratoire de quarantaine pour les pathogènes du Département d'Agriculture de Hawaii en décembre 1996. Parmi les 9 genres choisis dans la famille des Mélastomatacées et les 13 genres choisis dans l'ordre des Myrtales, seul M.c. a été sensible à l'infection par cet agent pathogène.* C. gloeosporioides miconiae *provoque des tâches foliaires de type anthracnose suivies par la défoliation prématurée des feuilles de* M.c.*. L'inoculation du pathogène sur des branches endommagées provoque le développement de chancres et entraîne le dépérissement de la branche. La maladie est disséminée par les spores ou les conidies qui sont produites dans des structures fructifères ou des acervuli. Comme une humidité ambiante est nécessaire pour la sporulation ainsi que pour la germination des conidies, cet agent pathogène de lutte biologique est supposé être plus efficace dans des zones humides et ventées.*

The serious threat and invasion of *Miconia calvescens* into the Hawaiian ecosystem (Gagné *et al*., 1992) prompted an immediate response from all resource levels to seek ways in which this noxious weed could be eradicated in Hawai'i (Conant *et al*., 1997). A biological control approach was recognized at this early stage of the *M.c.* control program as a complement to other eradication and control efforts. As a result, a cooperative biological control project was initiated by the Cooperative National Parks Resources Studies Unit at the University of Hawai'i at Manoa, between Robert Barreto, Plant Pathologist at the Federal University of Viçosa, Brazil, and the Biological Control Section of the Hawaii Department of Agriculture (HDOA). Barreto's contribution would be the search for pathogens of *M.c.* in Brazil where the plant species has its origins, and the HDOA's responsibility would include the testing and screening of any *M.c.* pathogen for biological control potential.

A result of this cooperative effort was the discovery of a fungal pathogen *Colletotrichum gloeosporioides*, which was isolated by Barreto from lesions on *M.c.* leaves collected from various locations in Brazil. In March 1996, several cultures of this organism

were sent to the HDOA's Plant Pathology Quarantine Facility, a high-level containment facility constructed to test non-indigenous plant pathogens. The pathogenicity of the fungal organism was confirmed according to Koch's postulates (proof of pathogenicity) soon after its arrival in Hawai'i. A host range testing program was initiated immediately.

THE FUNGUS *COLLETOTRICHUM GLOEOSPORIOIDES*

The pathogen isolated from *M.c.* was identified using descriptions of type species by Mordue (1971), von Arx (1957), and Sutton (1980). The identification of the species was also confirmed by Barreto. The fungus belongs to the Subdivision Deuteromycotina (Fungi Imperfecti), Class Coelomycetes, Order Melanconiales.

C. gloeosporioides causes typical anthracnose type of lesions on leaves of *M.c.* (**Fig. 1**) six to eight days after inoculation, followed by leaf abscission in three to four weeks. If a branch or stem is wound inoculated, the pathogen causes a canker or stem lesion (**Fig. 2**) which girdles the area, and ultimately causes dieback of the branch.

The fungus reproduces by means of asexual spores or conidia (**Fig. 3**) which are produced in fruiting structures called acervuli (**Fig. 4**). These acervuli appear on the surface of leaf spots under high humidity conditions. The conidia are dispersed by wind-driven rain, and germinate when there is free moisture on leaf surfaces. Upon germination a conidium produces a hyphal strand or mycelium, which forms an appressorium or pad-like structure. The adhesive quality of the appressorium keeps the hypha near the leaf surface. From the appressorium, the hypha then penetrates into the leaf epidermis. The lesion first appears as a small, dark, pinpoint-sized spot, which quickly expands. Acervuli are then produced within these lesions when conditions are favorable. Under artificial conditions, the fungus is easily cultured on 10% potato dextrose agar, sporulating moderately and producing a light pinkish-colored spore matrix.

The biocontrol potential of this *M.c.* pathogen was assessed on its leaf spotting and defoliating effect on *M.c.* plants and on the probability that the fungus was host specific to plants within the family Melastomataceae. Other races of *C. gloeosporioides* are well known for their host specificity and used as weed biological control agents. The Clidemia race of the same fungal species, *Colletotrichum gloeosporioides* f. sp. *clidemiae,* was identified and developed by Trujillo (1986) and Trujillo *et al*. (1986) as a biological control pathogen of *Clidemia hirta* (L.) D. Don, another noxious melastome weed in Hawai'i. The results of Trujillo's host specificity tests showed that *C. g. clidemiae* was very specific to *C. hirta* and did not infect *M.c.* although both genera belong to the same tribe Miconieae.

Another biocontrol agent, *C. gloeosporioides* f. sp. *aeschynomene*, the patented mycoherbicide "Collego" developed for the control of northern jointvetch, is also very specific in its host range. This biological control agent is only infective to members of the subfamily Faboideae (family Fabaceae or Leguminosae) (TeBeest, 1988).

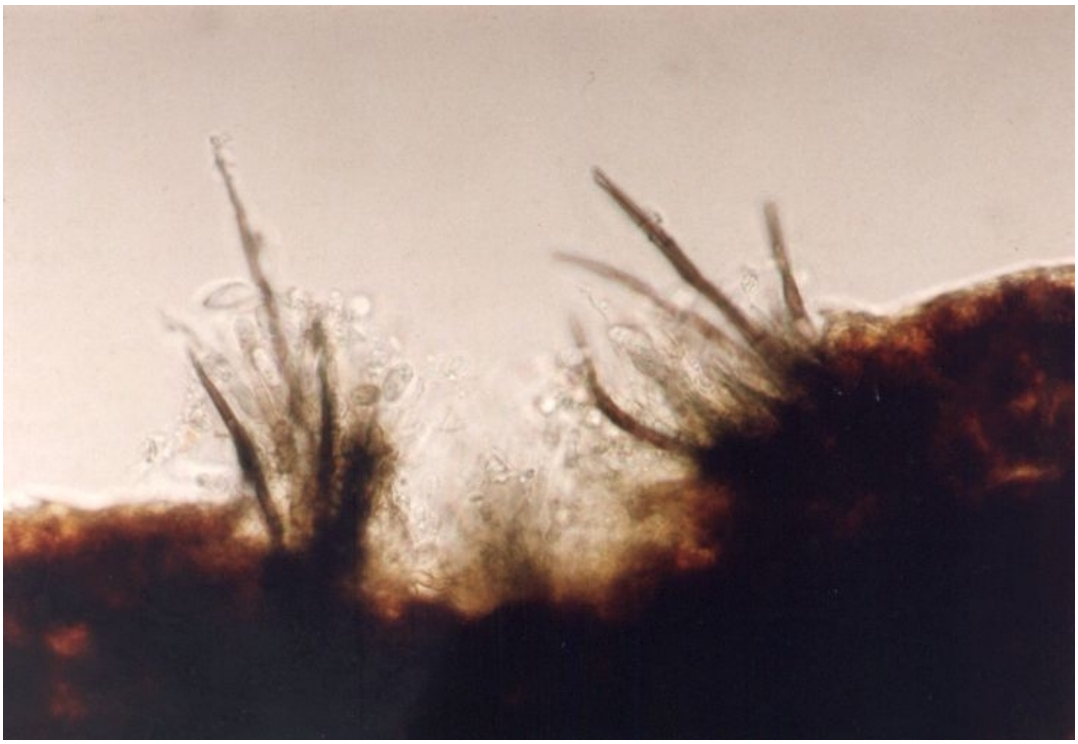
Since previous races or *formae speciales* of the fungal species *C. gloeosporioides* have been documented, the prospects were optimistic that the *M.c.* pathogen possessed similar host specific characteristics.

Fig. 1. Anthracnose type of leaf spots on leaves of *M.c.* 14 days after inoculation with conidia of *C.g. miconiae*. The oldest leaf is beginning to turn prematurely yellow due to the infection by the fungus.

Fig. 2. Wilting of young *M.c.* plants due to infection by wounding of stem area with conidia of *C. g. miconiae*. Plants were d one month after inoculation.

Fig. 3. Asexual spores or conidia of *C. g. miconiae* average 6.5 m in width and 22-25 m in length. They are produced abundantly in fungal fruiting structures and each is capable of causing an infection site.

Fig. 4. Cross section of an anthracnose leaf spot showing a section of an acervulus or fruiting structure of *C. g. miconiae*. The acervulus is ringed by dark, sterile hairs or setae.



HOST RANGE TESTING AND RESULTS

The centrifugal phylogenetic method of Wapshere (1974) was used in determining the host range of plants tested with the *M.c.* isolate of *C. gloeosporioides*. This method involves inoculating the potential biocontrol agent onto plant species closely related to the target weed, then moving on to species further removed and ending at that point where infection does not occur. In this case, plant species belonging to the family Melastomataceae were tested first. Of the other eleven genera in the family Melastomataceae, eight were tested. These included: *Clidemia hirta* (L.) D. Don; *Arthrostema ciliatum* Pav.ex D.Don.; *Dissotis rotundifolia* (Sm.) Trian; *Heterocentron subtriplinervium* (Link & Otto) A. Braun & C.; *Pterolepsis glomerata* (Rottb.) Miq.; *Tibouchina herbacea* (DC) Cogn.; *Medinilla scortechenii*; and *Melastoma candidum* D. Don. Other test plants represented the remaining families within the Order Myrtales.

Of all the plants tested, *M.c.* was the only susceptible host of the isolate of the *Colletotrichum gloeosporioides* from Brazil. None of the other Melastomataceae or plants belonging to the other families within the Order Myrtales became infected. These families included: Combretaceae (one species); Lythraceae (two species); Myrtaceae (ten species); Onagraceae (two species); and Thymelaceae (two species).

Since host range test results clearly defined a high level of specificity, the authors consider the pathogen isolated from M. calvescens is a race or *forma specialis* of *C. gloeosporioides* and have proposed the scientific name, *Colletotrichum gloeosporioides* f. sp. *miconiae*.

PERMITS AND RELEASE

Based on the results of the host range tests, the request for the field release of *C. gloeosporioides miconiae* was submitted to the State of Hawaii's Plant Quarantine Branch for approval on 31 December 1996. On 03 March 1997, the approval to release was granted. Shortly thereafter, another application was submitted to the federal or national agency for permission to release this fungus from the quarantine facility. The permit was granted on 11 July 1997.

The first field release occurred on 25 July 1997 on the island of Hawai'i. Due to the conditions attached to the permit, releases were made at only two sites. Fungal spore suspensions were sprayed onto *M.c.* plants in a designated area (6 m radial circle) at two locations, in Onomea and Pahoa. One month later, incipient disease spots appeared at both sites. After monitoring for disease development and spread for a one year period, additional areas may be targeted for releases.

DISCUSSION

Biological Control Prospects for Hawai'i--Natural infection of *M.c.* by *C. gloeosporioides miconiae* will result in leaf spotting and defoliation which in turn will slow the growth and development of *M.c.* plants. Under controlled conditions, tests have shown that artificially wounding and inoculating this pathogen causes cankering of branches. Whether the fungus will naturally infect *M.c.* stems or branches remain to be documented. If cankers caused by the pathogen are observed under field conditions, *C. gloeosporioides miconiae* will be a more effective biological control agent.

Dissemination of *C. gloeosporioides miconiae* is dependent on climatic conditions. The production of conidia or spores requires high humidity conditions. Wind-driven rain will dislodge and disperse the spores over a wide range. Fortunately, *M.c.* plants thrive under this type of environment so that existing climatic conditions will favor disease development

and dispersal of the fungus. It is expected that the disease will spread from inoculation sites quite readily.

The first release of the *C. gloeosporioides miconiae* was limited to two sites on the island of Hawai'i. No other release sites were permitted for a one year period. This restriction was imposed on the HDOA by the United States Fish and Wildlife Service (USFWS) whose agents were not completely confident in the safety of the fungus. Although extensive tests were completed and the results were scrutinized by scientists from various fields of study, restrictions were still levied. It is certain that with only two release sites, the pathogen's effect on controlling *M.c.* will be curtailed. The restraint by USFWS will be in effect for the first year. After 25 July 1998, the pathogen will be released at many sites within the *M.c.* infestation on the islands of Maui and Hawai'i and biological control activity by this *M.c.* pathogen will commence.

Prospects for Tahiti--Host specificity tests on plants in the Melastomataceae, endemic or indigenous to Tahiti, would be the first step in clearing the way to release this pathogen. Additional host testing would include native or endemic plants within the Order Myrtales. These have been identified, and testing of these plants will commence as soon as they have been propagated and shipped to the HDOA's Quarantine Facility in Honolulu.

Although the classical approach to biological control of *M.c.* may be appropriate for Hawai'i, it may not be the best way to approach the problem in French Polynesia where the *M.c.* infestation is extremely widespread (Meyer, 1994; 1996). An alternative method of inoculum preparation and application may be more effective and economical. Formulating the fungus as a mycoherbicide (Bowers, 1982; Boyette *et al*., 1991) will permit a more rapid means of pathogen production and release. For Hawai'i, this would be a major obstacle as herbicides (and mycoherbicides) are regulated by the U.S. Environmental Protection Agency and the process to clear any class of "herbicide" for public use would make it prohibitive. For Tahiti, this mode of pathogen application would be very advantageous.

Conclusion--For any biological weed control program, it is very difficult to predict the level of control that any one biocontrol organism will have on a target weed. For such a formidable weed as *M.c.*, one fungus, *C. gloeosporioides miconiae,* is not expected to eradicate this invasive weed. This pathogen will, however, reduce the weed's growth and vigor. Many biocontrol agents will be needed for a more effective control. A complex of natural enemies, including arthropods and other pathogens, would definitely increase the chances of controlling *M.c.* in Tahiti and Hawai'i.

The cooperative agreement between the governments of French Polynesia and Hawai'i to conduct the exploration for and the testing of natural enemies of *M.c.* will begin an international, biological control warfare against the invasive plant *M.c.*.

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MICONIA CALVESCENS, A POTENTIALLY INVASIVE PLANT IN AUSTRALIA'S TROPICAL AND SUB-TROPICAL RAINFORESTS

MICONIA CALVESCENS, *UNE PLANTE POTENTIELLEMENT ENVAHISSANTE DANS LES FORETS TROPICALES ET SUB-TROPICALES HUMIDES D'AUSTRALIE*

STEVE. M. CSURHES

Queensland Department of Natural Resources, Locked Bag 40, Coorparoo Delivery Centre 4151, Queensland, AUSTRALIA.

Miconia calvescens, a tree native to tropical America, is highly invasive in the rainforests of French Polynesia and Hawai'i. In 1963, *M.c.* was imported into the Townsville botanic gardens in North Queensland. During the 1970's it became a popular ornamental foliage plant in Australia and was sold by several nurseries in Queensland and New South Wales. Nurserymen have reported naturalised specimens in North Queensland, although the extent of these populations has not been fully assessed. Climatic modelling suggests that *M.c.* has the potential to invade tropical and sub-tropical rainforests of northern and eastern Australia. There appears to be an opportunity to prevent or contain the spread of *M.c.* in Australia. Legislation which prohibits cultivation and sale of *M.c.* and its congeners was put in place in Queensland in May 1997. A program to detect and eradicate cultivated and wild *M.c.* will be launched by the Queensland Government in 1997/98. Unfortunately, there are no legal barriers to sale and cultivation of *M.c.* in other States. Uniform national controls restricting trade in invasive plants such as *M.c.* are urgently required.

Miconia calvescens, *un arbre originaire d'Amérique tropicale, est fortement envahissant dans les forêts humides de Polynésie française et de Hawai'i. En 1963,* M.c. *a été importé dans les jardins botaniques de Townsville dans le Nord Queensland. Durant les années 70, il est devenu une plante ornementale populaire en Australie et a été vendu par plusieurs pépinières dans le Queensland et le New South Wales. Les pépiniéristes ont signalé des spécimens naturalisés dans le Nord Queensland, bien que l'étendue de ses populations n'a pas été totalement évaluée. Une modélisation climatique suggère que* M.c. *a le potentiel pour envahir les forêts humides tropicales et sub-tropicales du Nord et de l'Est de l'Australie. Une règlementation qui interdit la culture et la vente de* M.c *ainsi que les espèces du même genre a été mise en place au Queensland en mai 1997. Un programme pour détecter et éradiquer les pieds de* M.c. *cultivés ou sauvages sera lancé par le Gouvernement du Queensland en 1997/98. Malheureusement, il n'y a pas de barrières légales à la vente et à la culture de* M.c. *dans les autres États. Des contrôles uniformes nationaux limitant le commerce des plantes envahissantes comme* M.c. *sont nécessaires de toute urgence.*

Invasive plant species are usually first studied and reported after they have become extensively naturalized - at a time when eradication of the entire population is no longer feasible. In contrast, this paper draws attention to a potentially invasive plant, *Miconia calvescens*, which appears to have a very limited distribution in Australia. An assessment of the plant's pest potential is presented together with recommendations for preventive control. Hopefully, this species can be prevented from becoming an intractable problem in Australia.

DESCRIPTION AND BIOLOGY

M.c. is a tree native to Central and Southern America, from southern Mexico to northern Argentina; the bicolorous form is restricted to Central America (southern Mexico, northern Guatemala, Belize and Costa Rica) ; in its native habitat *M.c.* appears to be a shade-tolerant understory species that behaves as a pioneer tree in forest gaps (Meyer,

1994 ; 1996). It grows in lowland to montane tropical rainforest at altitudes between 300 and 1800 m (Wurdack,1980). Although capable of reaching 15m in height, the majority of specimens in the Society Islands are 6 to 12m tall, with slender, vertical stems (Meyer, 1996). The leaves are opposite, elliptic to obovate, usually 60-70 cm long (sometimes up to 1m long). Perhaps the most characteristic feature of the leaves is the three prominent longitudinal veins. The bicolorous form of the plant has leaves with purple undersides.

Under favorable conditions, juvenile specimens can grow up to 1.5m/year (Meyer and Malet, 1997) and reproduce when four to five years old (Meyer, 1996). The inflorescence is a large panicle comprised of 1000-3000 white or pink flowers. Flowering can occur three times per year and in Hawaii appears to be triggered by weather conditions (Medeiros *et al.,*1997). A young tree with only two panicles can produce ca. 200,000 seeds in its first fruiting season, whereas an older tree, with over 50 panicles, can produce over 5 million seeds per annum (Meyer, *op.cit.*). Berries are 6-7mm in diameter and turn purple or black when ripe. Each berry contains an average of 140-230 seeds, each ca. 0.7 by 0.5mm long (Meyer, op.cit.). Soil-seed banks containing more than 50,000 seeds per sq.m have been recorded in heavily infested areas (Gaubert, 1992). Seeds can remain viable for at least four years (Meyer and Malet, 1997). At Limberlost nursery in North Queensland, a seedling emerged five years after the parent tree had died (R. Jones, pers. comm. *in* Edwards, 1996). In a laboratory, some seeds germinate within 15-20 days when exposed to light and moisture, but others remain dormant (Meyer, 1996). Germination and seedling growth can occur under light levels as low as 0.02% of full sun (Meyer, 1994). This attribute facilitates the plant's persistence in deep shade beneath rainforest canopies.

Although most fruit falls beneath the parent tree, the seed is small enough to be moved by wind and water. In Tahiti, berries of *M.c.* are ingested by frugivorous birds, particularly the introduced silver-eye (*Zosterops lateralis*) and the red-vented bulbul (*Pycnonotus cafer*), which transport and defecate the seeds (Gaubert, 1992). Fruit can also be dispersed by frugivorous rodents (Meyer, 1994) and the tiny seed can adhere to mud on vehicles and shoes.

HISTORY AS A WEED ELSEWHERE

Due to the plant's attractive foliage *M.c.,* particularly the bicolorous form, has been grown as a garden ornamental throughout the world (Meyer, 1996). Originally introduced into the Papeari Botanical Garden (Tahiti) in 1937, *M.c.* has naturalized over 65% (ca. 70,000 ha) of the island and has formed dense, monospecific stands over 25% of the island (Meyer, *op.cit.*). It has spread to the surrounding islands of Moorea, Raiatea and Tahaa, and is ranked as the most important plant pest in the Society Islands (Meyer, *op.cit.*). *M.c.* was declared noxious by the French Polynesian Government in 1990.

Dense shade produced by the overlapping foliage of *M.c.* prevents regeneration of local rainforest plants to the extent that 70-100 native plant species, including 40-50 species endemic to French Polynesia, are directly threatened by invasion by *M.c.* (Meyer and Florence, 1996). *M.c.* persists in a wide range of habitats including primary and secondary rainforest in mesic and wet environments (mean annual rainfall >2,000mm) at 10-1300m elevation (Meyer, 1996). In areas of primary rainforest it appears to invade areas that show no obvious signs of disturbance.

On the island of O'ahu (Hawai'i), *M.c.* was present in the Wahiawa Botanical Gardens by 1961. It was subsequently sold by several Hawaiian nurseries and transported to other islands of Hawai'i. By 1990, it had formed pure stands in middle and high elevation rainforests up to 30km from the point of introduction (Loope and Medeiros, 1995). This is when control action was first undertaken in Hawaii. It was declared noxious in 1992 and in mid-1993 the Hawaii Department of Agriculture initiated biological control research. To date,

a range of fungi, weevils, leaf-feeding beetles, butterflies and moths have been found in South and Central America. Perhaps the most damaging species, the Chinese rose beetle (*Adoretus sinicus*), causes up to 50% defoliation but does not cause tree mortality (Medeiros *et al.*, 1997). Chemical control programs, including aerial spraying, have been undertaken in Hawai'i. Eradication appears feasible on some of the small islands, however, re-invasion from nearby islands and a resilient soil-seed bank associated with older stands are on-going problems (Meyer and Malet, 1997).

Cultivated specimens have been reported in the Philippines, Grenada and New Caledonia, whereas naturalized populations of *M.c.* exist in Jamaica and Sri Lanka (Meyer, 1996). Holm *et al.* (1979) list five other species of *Miconia* as weeds *(M. chamissois* Naud in Brazil*, M. laevigata* DC. in Jamaica*, M. lateriflora* Cogn. and *M. nervosa* Triana in Peru and *M. stenostachya* (Schr. & Mart.) DC. in Trinidad.

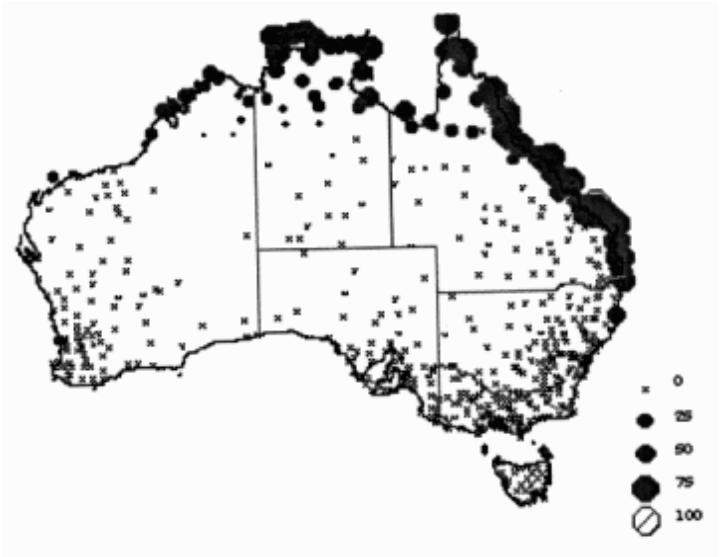
STATUS AND WEED POTENTIAL IN AUSTRALIA

In 1992, F. R, Fosberg, a botanist from the National Museum of Natural History (Smithsonian Institute) warned Australian authorities that "no expense be spared to search it (*M.c.*) out and destroy it before you have a hopeless problem" (Humphries and Stanton, 1992). More recently, it has been listed as a high priority candidate for eradication in Australia (Csurhes and Edwards, in press).

Using the CLIMEX computer program (Maywald and Sutherst, 1989; 1991), the potential distribution of *M.c.* has been predicted by P. Mackey (Edwards, 1996). The CLIMEX model confirmed the high suitability of climates in Tahiti and Hawaii (**Fig. 1**) and suggested that climates in northern and eastern Australia may be highly suitable (**Fig. 2**). Distribution and abundance of *M.c.* within the area of climatic suitability will, of course, be restricted by edaphic factors and land use. Since the plant has invaded mesic and wet rainforests in the Polynesian and Hawaiian archipelagoes it appears well suited to coastal, wet tropical and sub-tropical rainforest in eastern Australia (which occur primarily in Queensland).

Fig. 1. Predicted world distribution of *M.c.* (produced by Mackey *in* Edwards, 1996) (the size of the circles indicates the relative size of the climate match index).

Fig. 2. Predicted distribution of *M.c.* in Australia (produced by Mackey *in* Edwards, 1996) (the size of the circles indicates the relative size of the climate match index).



The impact of *M.c.* in Australian rainforest communities is difficult to predict. A worst case scenario is that the plant will have an impact comparable to that experienced in Tahiti, where it forms extensive pure stands. It has been suggested, however, that oceanic islands, such as Tahiti (which was formed by volcanic activity some 1M years ago), may be more vulnerable to invasions, due in part to a relatively impoverished flora (Loope and Mueller-Dombois, 1989; Meyer, 1996). Australia's older and generally more diverse rainforest communities may be more resilient to plant invasions. Accepting the worst case scenario, *M.c.* could form extensive, mono-specific stands in Australia's rainforests. As a consequence, native plants could be excluded and prevented from regenerating. Since *M.c.* can germinate and grow in very low light levels, it could invade and persist in relatively undisturbed primary rainforests.

Zosterops lateralis, one of the major avian dispersal vectors of *M.c.* in Tahiti, is abundant in eastern Australia ranging from Cape York to Tasmania. Within this range, *Z. lateralis* is migratory (Blakers *et al*., 1985) and is expected to be an effective dispersal vector throughout the plant's predicted range.

The earliest record of *M.c.* in Australia is the introduction of seeds from the Peridenya Botanical Gardens (Sri Lanka) to the Townsville Botanical Gardens in 1963 (Edwards, 1996). Specimens were subsequently cultivated in the Melbourne, Sydney and Mt Coot-tha (Brisbane) botanic gardens (Edwards, *op.cit.*). Several specimens were grown in the Flecker Botanic Gardens in Cairns but were removed in 1996, in response to a request from the Queensland Department of Natural Resources (local nursery owners have commented that people have sourced seeds of *M.c.* from specimens in these gardens prior to removal). The Queensland herbarium has two records of the plant, one from a private garden in Brisbane and another from a wholesale nursery in 1990. *M.c.* was common in Queensland nurseries in the 1970's, a period when exotic, tropical foliage plants were particularly popular. Investigation by the Queensland Department of Natural Resources in 1996 revealed that at least five nurseries in Queensland and at least three in New South Wales propagated and sold *M.c.* in the 1970's and 1980's. Nurserymen in the Cairns area sourced plants from Sydney and Tully in and around 1980 (Edwards, 1996). More recently, the plant appears to have gone out of "fashion" as a foliage species and few, if any, nurseries currently offer the plant for sale. In 1996, the Queensland Nursery Industry Association advised that the plant was not known to be in trade (in Queensland) and there was no opposition to its listing as a declared weed (as defined in the Queensland "Rural Lands Protection Act 1985").

To date, there are two reports of naturalized *M.c.* in Australia; one adjacent to rainforest north of Mossman and a second near El Arish in North Queensland. In both cases, naturalized specimens were derived from nearby nursery stock and private garden specimens. The extent of these infestations will be investigated by the Queensland Department of Natural Resources as part of a planned early detection and eradication program in 1997/98.

Since the plant has been cultivated in Queensland gardens for at least the past 20 years, a public awareness campaign has been implemented to help locate specimens. A color brochure on the plant is currently being distributed in Queensland. Hopefully, the plant can be detected and removed before it has a chance to become firmly naturalized.

Although *M.c.* was declared noxious in Queensland in May 1997, it can be legally cultivated and sold in all other States and Territories. Ideally, the plant should be prohibited from sale on a National basis to prevent interstate movement and naturalization.

CONCLUSION

M.c possesses attributes common to many of Australia's most invasive plants: high fecundity, rapid growth, shade tolerance, early reproductive maturity, long distance seed dispersal (by birds) and the persistence of a substantial seed bank in the soil. It appears well suited to the climates of coastal, eastern Queensland. Considering the plant's impact in the rainforests of Tahiti and Hawai'i, early detection and eradication of this plant in Australia is vital. Preventative measures, including uniform national restrictions over the plant's sale and cultivation, are required to preclude the need for more intensive control programs in the future.

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SESSION 3

GESTION DE *MICONIA CALVESCENS* ET DES PLANTES ENVAHISSANTES EN POLYNÉSIE FRANÇAISE

LÉGISLATION ET INFORMATION
LEGISLATION AND INFORMATION

ANNIE AUBANEL

Délégation à l'Environnement, B. P. 4562 Papeete, Tahiti, POLYNÉSIE FRANÇAISE.

Les invasions biologiques, causées ou accélérées par l'homme, ont été prises en compte par le législateur dès qu'elles ont eu un impact négatif sur certains secteurs économiques tels que l'agriculture (réglementations, phyto- et zoo-sanitaires) et évidemment aussi sur la santé des populations humaines.

Puis bon nombre de ces envahisseurs perturbant la nature, leur prise en compte est apparue dans les réglementations plus récentes relatives à la protection de la nature (décembre 1995 en Polynésie Française). En Polynésie vu le nombre d'îles (120) et leur grande sensibilité écologique, notre réglementation permet le contrôle de tout transfert d'une île à l'autre de spécimens vivants d'espèces menaçant la biodiversité et au niveau des importations n'autorise que des introductions d'espèces d'intérêt économique avec les meilleures garanties possibles sur le plan sanitaire et de leur innocuité sur la biodiversité.

Mais à quoi sert une réglementation si on ne garantit pas son application ? En la matière rien ne peut se faire sans l'adhésion et la participation des populations concernées qu'il faut donc informer et former. *Miconia calvescens*, par son invasion spectaculaire, a eu l'impact positif de développer ici une prise de conscience alors que de par le monde, l'homme de la rue, n'a pas encore compris qu'en matière d'introduction d'espèces on jouait avec le feu.

Biological invasions, either caused or accelerated by man, are taken into account by the legislative authorities as soon as they have a negative impact on certain economic sectors, such as agriculture (phytosanitary and zoosanitary regulations), and obviously on the health of human populations.

Since an increasing number of these invaders disturbed the environment they were included in more recent regulations (December 1995) relative to the conservation of nature in French Polynesia. Given the number of islands in Polynesia (120) and their major ecological sensitivity, our regulations provide for the control of the transport of living specimens of species which are a threat to biodiversity from one island to another. As far as imports are concerned, they only authorize the introduction of species of economic interest, with the best possible guaranties under a sanitary plan and provided that they are harmless to biodiversity.

But what is the use of regulations if their application is not guaranteed? Here, nothing can be done without the support and participation of the populations concerned, which must then be informed and trained. Miconia calvescens*, through its dramatic invasion, had a positive impact in a sense that people actually became aware of the problem, whereas elsewhere in the world the man in the street has not yet understood that introducing species is an extremely risky game.*

LE CONTRÔLE DE LA DISSÉMINATION INTER-ÎLES DE *MICONIA CALVESCENS* EN POLYNÉSIE FRANÇAISE

CONTROL OF MICONIA CALVESCENS *SPREAD BETWEEN ISLANDS IN FRENCH POLYNESIA*

DJEEN CHEOU & EMMANUEL NAUTA

Service du Développement Rural, Département de la Protection des Végétaux, B.P. 100 Papeete, Tahiti, POLYNÉSIE FRANÇAISE.

Le Département de la Protection des Végétaux (DPV) du Service du Développement Rural (SDR) a pour mission d'assurer la protection phytosanitaire de la Polynésie française en vue du développement des productions agricoles.

Il exerce en particulier un contrôle strict des introductions de végétaux et de produits végétaux aux frontières pour lesquels sont délivrés des permis d'importation à condition qu'ils soient exempts de parasites et de terre et qu'ils soient accompagnés d'un certificat phytosanitaire du pays d'origine.

De même, le DPV contrôle les transferts des plants ou parties de plantes entre les îles de Polynésie française. Les transports de terre sont soumis à fumigation préalable au bromure de méthyl (CH_3Br) pour éliminer les organismes nuisibles.

Toutes ces mesures, destinées à l'origine à la protection phytosanitaire des cultures agricoles, se révèlent également efficaces contre la dissémination de pestes végétales telles que *Miconia calvescens*.

The task of the DPV (Plant Protection Department), an agency of the Rural Development Service (SDR), is to insure the protection of plants in French Polynesia with the view of developing agricultural productivity.

It is particularly in charge of the strict control of plants and plant products introductions to French Polynesia. Such products are granted import licenses provided they are free from any parasites or soil and arrive with a phytosanitary certificate from the country of origin.

In the same way, the DPV controls the transfer of plants and plant parts between the islands of French Polynesia. Soil transfers are subject to prior fumigation using methyl-bromide (CH_3Br) *to kill noxious organisms.*

All these measures, originally adopted to protect agricultural crops, have actually proven effective against the spreading of plant pests such as Miconia calvescens.

SYNTHÈSE DE LA PARTICIPATION DU SDR* À LA LUTTE CONTRE *MICONIA CALVESCENS*

SYNTHESIS OF THE SDR ROLE IN THE CAMPAIGN AGAINST* MICONIA CALVESCENS

YOLANDE VERNAUDON & GABRIEL SAO CHAN CHEONG

Service du Développement Rural, B.P. 100 Papeete, Tahiti, POLYNÉSIE FRANÇAISE.

Les textes organisant le SDR* ne prévoient pas explicitement d'intervention de ce service en matière de protection de la nature et de gestion des espaces naturels. Sa mission principale est de réaliser les objectifs de développement agricole et forestier déterminés par le Gouvernement.

Cependant, dans un contexte écologique insulaire fragile, le développement ne peut perdurer que sur la base d'une gestion durable des ressources naturelles et le maintien des équilibres des écosystèmes.

C'est ainsi que les missions de police sanitaires d'une part et celles de gestion de la forêt et de l'espace rural, ainsi que le contrôle des activités cynégétiques d'autre part amènent le SDR à s'impliquer dans des actions très proches de la protection de la nature.

Par ailleurs, le SDR, service opérationnel, est doté de moyens humains et matériels relativement importants. En particulier son implantation s'étend sur tous les archipels de la Polynésie française où peuvent donc intervenir des agents de contrôle ou d'intervention sur le terrain.

C'est pourquoi le SDR vient régulièrement en appui des Délégations à la Recherche et à l'Environnement en matière de lutte contre *Miconia calvescens.*

* SDR : Service du Développement Rural

The regulations establishing the SDR (Rural Development Service) do not provide specifically for any intervention of this service regarding conservation of the environment or management of natural areas. Its main task is to achieve the agricultural and forest development objectives set by the Government.*

In a fragile insular ecological context, however, development can occur only if it is based on the sustainable management of natural resources and the maintenance of stable ecosystems.

Therefore, the phytosanitary objectives and operations of forest and rural space management on the one hand, as well as the control of hunting activities on the other hand, have led the SDR to get involved in operations akin to nature conservation.

Moreover, the SDR is present in every archipelago of French Polynesia so that its agents can directly carry out their missions or intervene in the field.

That is why the SDR regularly helps the Research Delegation and the Environment Delegation as far as control campaigns against Miconia calvescens *are concerned.*

** SDR : Service for Rural Development*

Vous avez déjà entendu deux exposés d'agents du SDR concernant notre participation à la lutte contre le *Miconia calvescens.*

Le premier, par notre équipe de Raiatea, dressait le bilan de la dernière campagne de lutte mécanique - par arrachage - menée en 1997 sur cette île. Depuis 1992, le SDR met régulièrement ses équipes au service de la stratégie de lutte établie pour Raiatea par les spécialistes (Mme Marie-Hélène Gaubert puis M. Jean-Yves Meyer - ORSTOM, Délégation à l'Environnement, Délégation à la Recherche).

Le second, que vous venez d'entendre, par le responsable de la police phytosanitaire, vous a permis de comprendre le rôle que pouvait jouer nos équipes dans le contrôle de la dissémination inter-îles de *M.c.* et autres pestes et ennemis de cultures.

Mon propos est de vous présenter plus généralement le SDR, ses missions, son organisation, afin de mieux appréhender sa participation dans une stratégie globale de lutte contre *M.c*, toutes ses possibilités mais aussi ses limites.

Avant d'aborder le corps du sujet, je vais vous relater un événement survenu récemment aux îles Marquises et qui illustre, en complément des deux exposés rappelés supra, les différentes facettes de nos interventions. Je reprendrai également cet exemple pour étayer ma conclusion. Du 22 juin au 3 juillet 1997, il y a deux mois de cela, M. Jean-Yves Meyer accompagnait deux botanistes du National Botanical Tropical Garden de Kaua'i en mission de prospection botanique aux îles Marquises. Ils avaient demandé, et obtenu, un soutien logistique (équipe, véhicule, logement) de la part du SDR. C'est ainsi que des agents du service les ont accompagnés sur le terrain au coeur de l'île de Nuku-Hiva. Là, ils ont découvert des plantules de *M.c*, ce qui est une catastrophe pour la flore locale. Le Ministère et la Délégation à la Recherche alertaient l'opinion publique par une conférence de presse (parution le 7 juillet 1997).
Dès le 26 juin 1997, le responsable du 5° SA (SDR Marquises) alertait la direction par courrier, sur cette découverte. Instruction lui était donnée, par retour du courrier, de mettre en place un dispositif de surveillance et d'information du public, ce qui fut fait dès le mois de juillet 1997.

PRESENTATION DU SDR

Le SDR est l'un des plus anciens services administratifs du territoire de la Polynésie française, il devient service de l'économie rurale à partir de 1967. Une récente révision de ses missions et de son organisation le nomme service du développement rural en 1994.

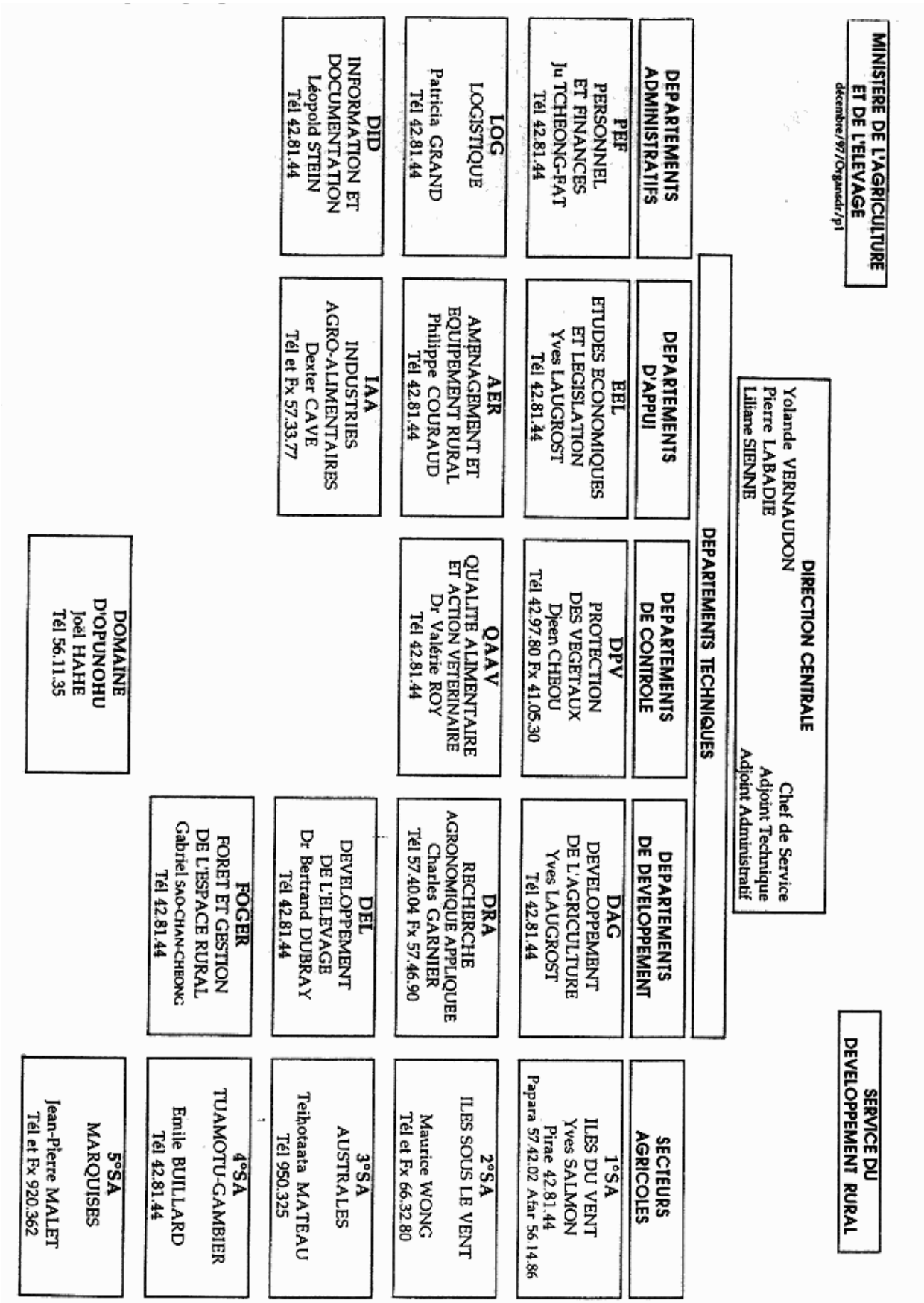
Comme tous les autres services administratifs du territoire, le SDR passe sous la tutelle du gouvernement territorial en 1984 avec l'avènement du statut d'autonomie interne. Il est ainsi fondamentalement chargé d'appliquer la politique territoriale dans les domaines d'intervention que le concerne.

Sa mission-- La délibération n° 94-159 AT du 22 décembre 1994 définit comme suit la mission du SDR : "Il réalise par tous les moyens mis à sa disposition les objectifs de développement agricole et forestier déterminés par le gouvernement".
Ladite délibération détaille les différents objectifs permettant de réaliser cette mission principale. Retenons notamment que le SDR est chargé de l'élaboration et de l'application de la réglementation phytosanitaire (art. 2, 4°), de l'élaboration et l'application de la réglementation forestière et cynégétique, de proposer toutes mesures de protection de la forêt et de restauration des sols (art. 2, 5°).

Son organisation-- Le SDR est un service opérationnel composé de départements et de secteurs agricoles placés sous la coordination d'une direction (**Fig.1**).

L'arrêté 446/CM du 24 avril 1995 portant organisation du SDR stipule que :
- les départements administratifs (au nombre de 3) sont chargés de la gestion administrative du service, de sa logistique et de la communication à l'intérieur du service ;
- les départements techniques (au nombre de 9) sont responsables de la conception, de la planification, de la gestion et du contrôle de l'application des programmes arrêtés par le ministère chargé de l'Agriculture, ainsi que de l'application de la réglementation dans le domaine de leur compétence sur l'ensemble du territoire.

Fig.1. Organigramme du SDR



Ces départements techniques sont de trois types :
- les départements d'appui au développement rural,
- les départements de développement opérationnel (notons le département de la forêt et gestion de l'espace rural),
- les départements de contrôle (notons le département de la protection des végétaux),
- le secteur agricole est une unité administrative regroupant dans une zone géographique déterminée totalité ou partie des activités relevant du SDR :
  - 1° SA pour la circonscription des I.D.V.,
  - 2° SA pour celle des I.S.L.V.,
  - 3° SA pour celle des Australes,
  - 4° SA pour celle des Tuamotu-Gambier,
  - 5° SA pour celle des Marquises.

Les moyens du SDR--

Moyens humains
Au 31 décembre 1996, le SDR comptait un effectif réel de 465 agents répartis sur l'ensemble du territoire de la Polynésie française. Cependant, le personnel d'encadrement ne représente qu'un peu plus de 10 % de l'effectif total. Il ressort de cette situation que les actions techniques du service sur le terrain restent insuffisantes et inadaptées aux besoins.

Moyens matériels (p.m.)

Moyens financiers
Les crédits de fonctionnement affectés au SDR se sont montés à 274 millions de francs dont 16 millions pour les opérations du contrat de développement.
Le budget d'investissement a concerné principalement les opérations du contrat de développement. Au 31 décembre 1996, les engagements pour l'ensemble des opérations menées en cours d'année s'élèvent à 429 millions de francs.

Ses actions-- Pour avoir des détails sur les actions réalisées par le SDR on pourra se reporter aux différents rapports d'activités annuels. Signalons cependant :
- 1.887.000 FCP inscrits pour diverses opérations du contrat de développement (1994 - 1998) ;
- La gestion de la D.D.A ;
- Le R.G.A. ;
- Les actions de recherche et de développement (animation, vulgarisation) des diverses filières techniques végétales, animales et agro-industries ;
- Les activités forestières (forêt de production) : inventaire, plantation, entretien ;
- Les actions de police sanitaire ;
- Les travaux d'équipement rural et la gestion des domaines territoriaux affectés au service.

***L'opération d'éradication de la mouche des fruits orientale* B. dorsalis--** Il m'est apparu nécessaire d'évoquer, au moins rapidement dans le cadre de cette conférence sur la lutte contre *M.c.,* une autre action de lutte contre une espèce indésirable, nuisible des cultures, l'opération d'éradication de la mouche des fruits orientale *Bactrosera dorsalis.*
Décelée en juillet 1996, la *B. dorsalis* a vraisemblablement infesté l'île de Tahiti, puis celle de Moorea à partir de l'introduction malencontreuse d'un fruit contaminé en provenance de Hawaii. Deux espèces de mouches des fruits avaient été antérieurement introduites sur le territoire et se sont depuis réparties sur de nombreuses îles : *B. kirkii* et *B. tryoni*. La *B. dorsalis* apparaissant beaucoup plus néfaste encore que les deux précédentes, dès août 1996 le gouvernement de la Polynésie française décide de mettre en place une opération d'éradication de cette *B. dorsalis*.

L'application de l'opération est confiée au SDR qui reçoit un appui en moyens humains de la Chambre d'agriculture. La stratégie de l'opération est proposée par des experts

régionaux et adaptée au contexte local. Les principales actions liées à cette opération consiste à :
- attirer et tuer les mouches mâles par la pose régulière d'appâts qu'il a fallu préalablement préparer ;
- attirer et tuer les mouches femelles dans les foyers d'infestation par la pulvérisation d'un autre type d'appâts ;
- surveiller l'évolution de la population de cette mouche sur Tahiti et Moorea et contrôler qu'elle n'a pas infesté d'autres îles ;
- intensifier le contrôle des échanges inter-îles ;
- informer le public.

En phase d'application depuis janvier 1997, cette opération mobilise une grande partie des moyens humains et en véhicules du SDR sur Tahiti et Moorea et devrait se poursuivre jusqu'à la fin de l'année.
Un total de 60 millions de francs ont été exceptionnellement mobilisés par le gouvernement pour financer ces actions. Il convient de noter que pour ce type d'opération la rapidité de réaction des pouvoirs publics est un facteur essentiel de succès et de réduction des coûts.

POSSIBILITES DU SDR A UNE PARTICIPATION DANS LA LUTTE CONTRE LE MICONIA

Si vous avez suivi mon exposé jusqu'à maintenant vous devriez vous demander pourquoi le SDR participe à la lutte contre *M.c.* ?

Un coup d'envoi conjoncturel ?-- La première campagne d'arrachage de *M.c.* à laquelle s'est associée le SDR sur Raiatea date de 1992. Or de 1992 à 1994 les portefeuilles de l'agriculture et de l'environnement étaient regroupés au sein d'un même ministère. Madame H. Lagarde, Ministre de l'Agriculture, de l'Environnement et de la Condition féminine veillait en même temps sur la politique de développement agricole et sur celle de protection de la nature.
Il est évident que de tels regroupements sous la tutelle d'un même ministre favorisent les relations entre services administratifs.
Il faut souligner qu'au niveau du service, le terrain était favorable, puisque de nombreux agents du SDR sont, à titre personnel, très impliqués dans des actions de protection de l'environnement et ne comptent pas leur temps et leurs moyens pour cela.

Une politique générale de développement durable-- Nous l'avons vu, la mission du SDR porte principalement sur le développement des activités agricoles et forestières.
Cependant, deux points ne doivent pas être perdus de vue :

<u>L'administration territoriale,</u>
Bien que divisée en un certain nombre de services aux missions sectorisées, constitue une entité. Les politiques sectorielles s'inscrivant elles-mêmes dans une politique globale et générale du gouvernement.
Parmi les grands axes de la politique globale définie par le gouvernement figure la protection de l'environnement.
Ainsi, le SDR, service doté de moyens opérationnels de terrain, doit apporter sa contribution à la réalisation de cet axe majeur de la politique gouvernementale.

<u>La notion de développement durable</u>
Le SDR doit réaliser les objectifs de développement agricole et forestier déterminés par le gouvernement mais ce développement doit être assuré pour le futur autant que pour le présent.
Dans le contexte écologique riche mais particulièrement fragile de nos îles, une trop grande négligence des équilibres de nos écosystèmes pénalise rapidement nos atouts pour un développement durable.

C'est pourquoi on peut considérer que le SDR accomplit indirectement sa mission en participant à des actions de protection de la nature.

L'existence de moyens opérationnels
Nous l'avons vu, le SDR est doté de moyens opérationnels importants sur l'ensemble de la Polynésie française. Ces moyens paraissent encore plus conséquents si on les compare à ceux des délégations à l'environnement et à la recherche.

La police phytosanitaire
Les contrôleurs et agents auxiliaires de contrôle constituent un réseau de surveillance, comme cela vous a été exposé par le chef du département de la protection des végétaux, sur une grande partie des îles de la Polynésie française.
Ce dispositif chargé de veiller à l'état sanitaire de nos cultures, peut permettre, avec un minimum d'organisation, un contrôle des risques d'introduction d'espèces menaçantes pour notre environnement.

Les équipes forestières
Près de 170 agents constituent les équipes forestières chargées de l'entretien des pistes forestières, de plantation et d'entretien des massifs de production de bois.
Ces équipes rompues aux activités de terrain sont peuvent être pour des actions de lutte mécanique contre *M.c*.

Une certaine expérience en matière de lutte contre les pestes
- Èradication de *B. dorsalis* sur Tahiti et Moorea
- Èradication du *Merremia peltata* sur Rurutu

LES LIMITES DE NOS INTERVENTIONS

Seulement les actions de terrain-- Vous l'aurez remarqué, le SDR intervient dans la lutte contre *M.c.* uniquement par des actions de terrain, qu'il s'agisse de contrôle et de surveillance ou de lutte mécanique et chimique. Ces interventions ne constituent qu'un volet d'une stratégie d'ensemble qui doit comprendre aussi, pour être efficace, un volet recherche, un autre sur la réglementation et un autre d'information et de sensibilisation.

Comme le soulignait le docteur Patrick Howell, Ministre de la Santé et de la Recherche, nous serions bien en peine de lutter mécaniquement contre *M.c.* sur les 70 000 ha envahis sur l'île de Tahiti. D'autres modes de lutte doivent être trouvés. De la même manière, sans une réglementation plus claire et une information du public plus intense, la dissémination de cette peste risque de progresser plus vite que nos succès pour l'endiguer.

Recherche, réglementation et information ne sont en aucune manière du ressort du SDR en ce qui concerne *M.c*.

Des moyens limités par rapport aux actions prioritaires du SDR-- Je l'ai rapidement évoqué supra, les actions de développement agricole et forestier assignées au SDR sont nombreuses et mobilisent l'ensemble de nos moyens humains, matériels et financiers, aussi importants que ces derniers puissent vous paraître.
Jugé avant tout sur le degré d'accomplissement de sa mission, le service mobilise ses moyens en priorité sur des actions de développement ou sur des actions de contrôle et de lutte contre des espèces menaçant directement les activités agricoles et forestières.

CONCLUSION

Reprenons la découverte récente d'une infestation de l'île de Nuku-Hiva par I*M.c.*. Je vous ai indiqué comment le SDR a déjà réagi face à cette infestation.

Mais interrogeons-nous un moment sur les hypothèses d'introduction de cette peste à Nuku-Hiva. Il est probable que la contamination ait eu lieu par la terre transportée dans un train de chenille ou par des roues de gros engins de travaux publics.

Il y a donc défaillance de l'information : de nombreuses personnes ne sont pas conscientes des risques majeures de contamination des îles - par *M.c.* ou par bien d'autres espèces - qu'elles prennent en transportant sciemment ou non de la terre et des produits végétaux et animaux.

Il y a aussi des limites aux moyens de notre police sanitaire qui ne peut se trouver dans toutes les vallées ou débarqueraient des caboteurs publics ou privés ou encore des yachts privés.

Or, face à la menace majeure que représente *M.c.* pour la flore de Polynésie et en l'absence de moyen de lutte facile à déployer, il est essentiel de mettre l'accent sur la prévention.

D'autres services administratifs pourraient utilement venir en appui d'une stratégie globale de lutte contre *M.c*.

On pense naturellement au service de l'éducation en matière de sensibilisation du public.

On pourrait également se tourner vers la direction de l'équipement, qui mieux informée, pourrait aider, au moins passivement, au bon déroulement de cette stratégie. En effet, par l'application de quelques règles simples de précaution, les risques de propagation des pestes par les chantiers de travaux publics pourraient être considérablement réduits.

Cet exposé, qui n'a aucun caractère scientifique comme vous l'aurez remarqué, vise un objectif : que la stratégie de lutte contre *M.c.* soit réaliste, ainsi elle nous mènera au succès.

PERSPECTIVES D'AVENIR POUR LA LUTTE CONTRE *MICONIA CALVESCENS* EN POLYNÉSIE FRANÇAISE : STRATÉGIE GÉNÉRALE ET TACTIQUES DE TERRAIN

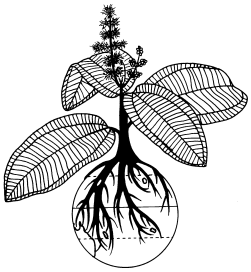
FUTURE PROSPECTS FOR MICONIA CALVESCENS *CONTROL IN FRENCH POLYNESIA : GENERAL STRATEGY AND FIELD TACTICS*

JEAN-YVES MEYER[1, 2]

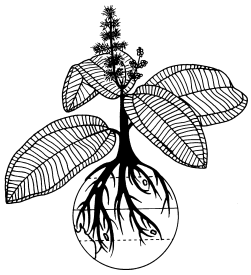
[1]Délégation à la Recherche, B.P. 20981 Papeete, Tahiti, POLYNÉSIE FRANÇAISE.
[2]Cooperative National Park Resource Studies Unit, Botany Department, University of Hawaii at Manoa, Honolulu, HAWAII (USA).

Basée sur plus de 5 années d'expérience acquise tant dans le domaine de la recherche que dans la gestion sur le terrain, la meilleure stratégie de lutte contre *Miconia calvescens* en Polynésie française apparaît être : 1) une information et une sensibilisation accrue du public et des autorités locales afin d'empêcher toute introduction volontaire ou accidentelle de *M.c.* dans les îles encore non touchées par l'invasion ; 2) un renforcement de la lutte manuelle et chimique dans les zones peu envahies et facilement accessibles ; 3) la mise au point d'une méthode efficace de lutte biologique pour parvenir à contrôler *M.c.* dans les zones très envahies ou inaccessibles ; 4) le suivi sur un long terme de l'efficacité des différents types de lutte. Les tactiques de lutte à appliquer sur le terrain peuvent diffèrer selon les situations : dans les îles peu envahies, la prospection sur le terrain et la reconnaissance aérienne, pour repérer et détruire tous les individus isolés, doit être renforcée ; dans les îles très envahies, la définition d'aires de contrôle intensif de *M.c.* dans les zones naturelles d'intérêt écologique doit constituer une priorité. Le succès de cette stratégie générale ne peut reposer que sur une collaboration étroite entre les différents Ministères de Polynésie française (Agriculture, Environnement, et Recherche) et les Services sous leur tutelle : la création d'un comité inter-ministériel, qui proposera un plan d'action sur un long-terme accompagné d'un financement approprié, est proposé.

Based on more than 5 years experience, both in research and field management, the best strategy to control Miconia calvescens *in French Polynesia appears to be: 1) more education and information for the public and local authorities to prevent voluntarily or accidental introductions of* M.c. *into non-infested islands; 2) reinforcement of manual and chemical control efforts in low-level infestations and easily accessible areas; 3) development of effective biocontrol to control* M.c. *in highly invaded and inaccessible areas; 4) long-term monitoring of the effectiveness of the different control methods. Control tactics in the field will vary according to the situation: on islands with low levels of infestation, ground-scouting and aerial reconnaissance to locate and eliminate isolated individuals should be reinforced; on the heavily invaded islands, native areas of ecological interest should be identified and the intensive control of* M.c. *should be prioritized in these areas. The success of this general strategy requires the collaboration of the French Polynesian Ministries (Agriculture, Environment, and Research) and their respective executive agency. The creation of an inter-ministerial committee to propose and implement a long-term action plan with adequate funding is proposed.*



ANNEXES



PROGRAMME DE LA CONFÉRENCE

MARDI 26 AOUT / *TUESDAY, AUGUST 26*
Institut Mathilde Frébault (Papeete)

7:30 am Accueil / *Welcome*

8:00 am Discours d'ouverture du Président du Gouvernement de Polynésie française, lu en français par :
***M. Édouard Fritch**, Vice-Président, Ministre de la Mer, du Développement des Archipels et des Postes et Télécommunications.*
lu en anglais par :
***Dr. Patrick Howell**, Ministre de la Santé et de la Recherche*.

SESSION 1 : ÉTUDES ET LUTTE CONTRE *MICONIA CALVESCENS* EN POLYNÉSIE
Président de séance : Isabelle Pérez, Déléguée à la Recherche

8:15 am Présentation des intervenants.
***Dr. Isabelle Pérez**, Délégation à la Recherche.*

8:30 am Les végétaux vasculaires indigènes de la Société : situation actuelle, menaces et perspectives de sauvegarde.
***Dr. Jacques Florence**, ORSTOM/Muséum national d'Histoire naturelle, Paris.*

9:00 am Épidémiologie de l'invasion par *Miconia calvescens* et raisons d'un succès spectaculaire.
***Dr. Jean-Yves Meyer**, Délégation à la Recherche/University of Hawai'i, Botany Department.*

9:30 am Bilan de la campagne d'arrachage de *Miconia calvescens* aux Iles-Sous-le-Vent en 1997 et stratégie future.
***Dr. Maurice Wong**, Chef du 2ème Secteur Agricole, Service du Développement Rural, Raiatea.*

10:00 am-10:30 am : Pause-café / *Coffee-break*

SESSION 2 : ÉTUDES ET LUTTE CONTRE *MICONIA CALVESCENS* AUX ÎLES HAWAI'I
Président de séance : Jean-Yves Meyer

10:30 am Présentation des intervenants.
***Dr. Jean-Yves Meyer**, Délégation à la Recherche/University of Hawai'i, Botany Department.*

10:45 am Control of infestations originating from single *Miconia calvescens* plants on O'ahu and Kaua'i (Hawai'i).
***Patrick Conant**, Hawaii Department of Agriculture, Honolulu.*

11:15 pm Control of *Miconia calvescens* in Hawai'i County (Big Island, Hawai'i).
***Kim Tavares**, Big Island Miconia Control Program, RCUH/Hawaii Department of Agriculture, Hilo.*

11:45 am-13:45 pm : Déjeuner / *Lunch*

14:00 pm Interagency efforts to combat *Miconia calvescens* on the island of Maui, Hawai'i.
***Arthur Medeiros**, USGS/BRD, Haleakala National Park, Maui.*

14:30 pm Prospective biological control of *Miconia calvescens* in Hawai'i with a non indigenous fungus *Colletotrichum gloesporioides* f. sp. *Miconiae*.
***Dr. Eloise Killgore**, Hawaii Department of Agriculture, Honolulu.*

15:00 am *Miconia calvescens*, a potential weed of Australia's tropical and subtropical rainforests.
***Steve Csurhes**, Queensland Department of Natural Ressources, Australia.*

Remplacé par :
Major broad-leaved weeds in the western insular Pacific environment and prospects for their biological control.
***Dr. Michael Doyle**, South Pacific Regional Herbarium, University of the South Pacific, Suva, Fiji.*

15:30 pm **PRESENTATION DES POSTERS / *POSTER SESSION***

Le Programme de la Flore de Polynésie française.
***Dr. J. Florence**, ORSTOM/Muséum national d'Histoire naturelle, Paris.*

Natural Enemies of *Miconia calvescens*: Biological Control Possibilities.
***P. Conant, E. Killgore, L. Sugiyama & R. Burkhart,** Hawaii Department of Agriculture, Honolulu.*

La lutte contre *Miconia calvescens* aux îles Hawaii. Sensibilisation, Prévention et Actions.
***Dr. J.-Y. Meyer**, Délégation à la Recherche/University of Hawaii, Botany Department.*

MERCREDI 27 AOUT / *WEDNESDAY, AUGUST 27*
Institut Mathilde Frébault (Papeete)

7:30 am Accueil / *Welcome*

SESSION 3 : GESTION DES PLANTES ENVAHISSANTES EN POLYNÉSIE
Président de séance : François-Xavier Bard, Directeur du Centre ORSTOM de Tahiti

7:45 am Présentation des intervenants.
Dr. Isabelle Pérez*, Délégation à la Recherche.*

8:00 am Le contrôle de la dissémination inter-île de *Miconia calvescens*.
Djeen Tcheou*, Département de la Protection des Végétaux, Service du Développement Rural.*

8:30 am Synthèse de la participation du S.D.R. à la lutte contre *Miconia calvescens*.
Yolande Vernaudon*, Chef du Service du Développement Rural.*

9:00 am Législation et information**.**
Dr. ***Annie Aubanel****, Chef de la Délégation à l'Environnement.*

9:30 am Perspectives d'avenir pour la lutte contre *Miconia calvescens* en Polynésie française : stratégie générale et tactiques de terrain.
Dr. Jean-Yves Meyer*, Délégation à la Recherche/University of Hawai'i, Botany Department.*

10:0 am-10:30 am : Pause-café / *Coffee-break*

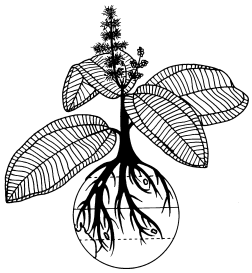
10: 30 am **DISCUSSION FINALE / *FINAL DISCUSSION***
Rapporteurs / *Moderators* : Isabelle Pérez & Jean-Yves Meyer

JEUDI 28 AOUT / *THURSDAY, AUGUST 28*

Sortie sur le terrain / *Field trip* : traversée de l'île de Tahiti Nui en 4x4 / *crossing of the island of Tahiti Nui with a 4WD.*

VENDREDI 29 AOUT / *FRIDAY, AUGUST 29*

Sortie sur le terrain / *Field trip* : montée sur le plateau de Taravao (Tahiti Iti) en 4x4 et petite randonnée à pied dans une forêt à *Miconia* / *drive up to the plateau of Taravao (Tahiti Iti) with a 4WD and small hike in a* Miconia *forest..*



COMITÉ ORGANISATEUR

DELEGATION A LA RECHERCHE
B.P. 20981 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 46 00 89
Fax : (689) 43 34 00
E.mail : recherch@mail.pf

Isabelle PEREZ
Déléguée

Émilie FAUA
Secrétaire

Jean-Yves MEYER
Chargé de recherche

CENTRE ORSTOM DE TAHITI
B.P. 529 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 43 98 87
Fax : (689) 42 95 55

Maeva CRAWLEY
Secrétaire

Corinne OLLIER
Dessinatrice

Roger THERY
Documentaliste

SERVICE DE LA TRADUCTION ET DE L'INTERPRETARIAT
B.P. 9040 Fare Ute, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 43 21 40
Fax : (689) 43 53 37

Yan PEIRSEGAELE
Interprète

LISTE ET ADRESSE DES PARTICIPANTS

Annie AUBANEL
Délégation à l'Environnement
B.P. 4562 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 43 24 09
Fax : (689) 41 92 52

Olivier BABIN
Service de l'Urbanisme
B.P. 866 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 46 80 23
Fax : (689) 43 49 83

François-Xavier BARD
Centre ORSTOM de Tahiti
B.P. 529 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tel. : (689) 43 98 87
Fax : (689) 42 95 55
E.mail : bard@rio.net

Paula BAYLET-MEYER
Ministère de l'Environnement
B.P. 2551 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 54 25 54
Fax : (689) 45 62 43

Émile BROTHERSON
Service du Développement Rural
B.P. 13 Uturoa, Raiatea
POLYNÉSIE FRANÇAISE
Tél. : (689) 66 32 80
Fax : (689) 66 32 80

Djeen CHEOU
Service du Développement Rural
Département de la Protection des Végétaux
B.P. 100 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 42 81 44
Fax : (689) 42 08 31

Patrick CONANT
Hawaii Department of Agriculture
Plant Pest Control Branch
1428 South King Street
Honolulu, HAWAII 96814, USA
Tél. : (808) 974 4140
Fax : (808) 974 4148

Maeva CRAWLEY
Centre ORSTOM de Tahiti
B.P. 529 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 43 98 87
Fax : (689) 42 95 55

Steve M. CSURHES (absent)
Queensland Department of Natural Resources
Locked Bag 40, Coorparoo Delivery Centre 4151
Brisbane, AUSTRALIA
Tél. : (0011) 61 7 340 62870
E.mail : csurhes@citec.qld.gov.au

Freddy DHAUSSY
S.A.R.L. Tefaarahi Adventure Tours
B.P. 140067 Arue, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 41 97 99
Fax : (689) 53 21 22

Michael F. DOYLE
South Pacific Regional Herbarium
The University of the South Pacific
P.O. Box 1168 Suva, FIJI
Tél. : (679) 212-007
Fax : (679) 315 601 / (679) 302 548
E.mail : Doyle_M@USP.AC.FJ

Alban ELLACOTT
T.E.P.
(Société de Transport et d'Énergie électrique en Polynésie)
B.P. 4606 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 43 19 00
Fax : (689) 43 28 45

Émilie FAUA
Délégation à la Recherche
B.P. 20981 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 46 00 89
Fax : (689) 43 34 00
E.mail : recherch@mail.pf

Marc FAARUIA
Institut Territorial de Recherches Médicales
Louis Malardé
B.P. 30 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 41 64 64
Fax : (689) 43 15 90

Jacques FLORENCE
Muséum National d'Histoire Naturelle
Laboratoire de Phanérogamie
16, rue Buffon
75005 Paris, FRANCE
Tél. : (33) 1 40 79 33 53
Fax : (33) 1 40 79 33 42
E.mail : florence@cimrs1.mnhn.fr

Eloise M. KILLGORE
Hawaii Department of Agriculture
Biological Control Section
1428 South King Street
Honolulu, HAWAII 96814, USA
Tél. : (808) 973 9546
Fax : (808) 973 9533
E.mail : elopath@elele.peacesat.hawaii.edu

Frédéric LARDEUX
Institut Territorial de Recherches Médicales
Louis Malardé
UR Entomologie médicale
B.P. 30 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 41 64 50
Fax : (689) 43 15 90
E-mail : lardeux@tahiti.rio.net

Isabelle LECHAT
Institut Territorial de Recherches Médicales
Louis Malardé
UR Plantes aromatiques
B.P. 30 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 41 64 16
Fax : (689) 43 15 90
E-mail : ilechat@tahiti.rio.net

Matthieu LEQUEUX
B.P. 886 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 41 04 58

Lloyd L. LOOPE
USGS/BRD
(US Geological Service/Biological Resource Division)
Haleakala National Park
P.O. Box 369, Makawao
Maui, HAWAII 96768, USA
Tél. : (808) 572 9306
Fax : (808) 572 130
E.mail : lloyd_loope@nbs.gov

Arthur C. MEIDEROS
USGS/BRD
Haleakala National Park
P.O. Box 369, Makawao
Maui HAWAII 96768, USA
Tél. : (808) 572 9306
Fax : (808) 572 130

Jean-Yves MEYER
Délégation à la Recherche
B. P. 20981 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 46 00 89
Fax : (689) 43 34 00
E.mail : recherch@mail.pf

Olivier MONTLAHUC
S.E.D.E.P.
(Société d'Étude et de Développement Électro-technique Polynésienne)
B. P. 5109 Arue, Tahiti
Tél. : (689) 41 48 79
Fax : (689) 43 28 78

Véronique MU-LIEPMANN
Musée de Tahiti et des Iles
B.P. 380354 Punaauia, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 58 34 76
Fax : (689) 58 43 00

Emmanuel NAUTA
Service du Développement Rural
Département de la Protection des Végétaux
B. P. 100 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 42 81 44
Fax : (689) 42 08 31

Corinne OLLIER
Centre ORSTOM de Tahiti
B.P. 529 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tel. : (689) 43 98 87
Fax : (689) 42 95 55
E.mail : ollier@rio.net

John PAOAAFAITE
Centre ORSTOM de Tahiti
B.P. 529 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 43 98 87
Fax : (689) 42 95 55

Claude PAYRI
Centre Universitaire de Polynésie Française
Laboratoire d'Écologie Marine
B.P. 6570 Faaa, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 80 38 32
Fax : (689) 80 38 04
E.mail : payri@ufp.pf

Yan PEIRSEGAELE
Service de la Traduction
et de l'Interprétariat
B.P. 9040 Fare Ute, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 43 21 40
Fax : (689) 43 53 37

Isabelle PEREZ
Délégation à la Recherche
B. P. 20981 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 46 00 89
Fax : (689) 43 34 00
E.mail : recherch@mail.pf

Gabriel SAO CHAN CHEONG
Service du Développement Rural
B.P. 100 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 42 81 44
Fax : (689) 42 08 31

Yves SÉCHAN
Institut Territorial de Recherches Médicales
Louis Malardé
UR Lutte anti-vectorielle
B.P. 30, Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 41 64 64
Fax : (689) 43 15 90

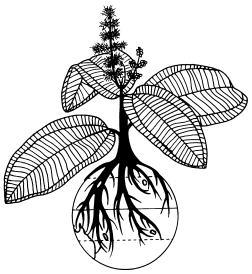
Clifford W. SMITH
University of Hawaii at Manoa
Department of Botany
Cooperative National Park Resource Studies Unit
3190 Maile Way, St John # 409
Honolulu, HAWAII 96822-2279, USA
Tél. : (808) 956 8218
Fax : (808) 973 2936
E-mail : cliff@hawaii.edu

Édouard SUHAS
Institut Territorial de Recherches Médicales
Louis Malardé
B.P. 30 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 41 64 16
Fax : (689) 43 15 90

Kim TAVARES
Miconia Control Program
Hawaii Department of Agriculture
16 E. Lanikaula Street
Hilo, HAWAII 96720, USA
Tél. : (808) 974 4140
Fax : (808) 974 4148
E.mail : vbg@interpac.net

Yolande VERNAUDON
Service du Développement Rural
B.P. 100 Papeete, Tahiti
POLYNÉSIE FRANÇAISE
Tél. : (689) 42 81 44
Fax : (689) 42 08 31

Maurice WONG
Service du Développement Rural
B.P. 13 Uturoa, Raiatea
POLYNÉSIE FRANÇAISE
Tél. : (689) 66 32 80
Fax : (689) 66 32 80
E.mail : sdrwong@mail.pf



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Gouvernement de Polynésie française

Ministère de la Santé
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B.P. 20981 Papeete TAHITI
Téléphone : (689) 46 00 89
Télécopie : (689) 43 54 00

L'Institut Français de Recherche Scientifique pour le Développement en Coopération
Centre de Tahiti, B.P. 529, Papeete